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WITH THE COMPLIMENTS OF
THE BOARD OF TRADE OF
THE CITY OF TORONTO

OFFICIAL REPORT
OF THE
ONTARIO POWER COMMISSION

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TORONTO

Hydro Electric Power Commission

WITH THE COMPLIMENTS OF
THE BOARD OF TRADE OF
THE CITY OF TORONTO.

OFFICIAL REPORT
of the
ONTARIO POWER COMMISSION

March 28th 1906

PRINTED BY
THE MONETARY TIMES PRINTING COMPANY OF CANADA, LIMITED,
TORONTO

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Commissioners

E. W. B. SNIDER, Esq. *(Chairman)*	Waterloo, Ont.
P. W. ELLIS, Esq. *(Vice-Chairman and Treasurer)*	Toronto, Ont.
W. F. COCKSHUTT, Esq., M.P.	Brantford, Ont.
The Hon. ADAM BECK, M.P.P.	London, Ont.
Professor R. A. FESSENDEN	Washington, D.C.

James C. Haight, Esq., Barrister, Waterloo, Ont., acted as Secretary to the Commission.

PREFACE

An Act was passed by the Ontario Legislature in 1903 entitled "An Act to Provide for the Construction of Municipal Power Works and the Transmission, Distribution and Supply of Electrical and Other Power and Energy" (Cap. 25, 3 Ed. VII., 1903), which authorized Ontario municipalities to appoint a Commission to inquire into the "feasibility and desirability of securing the establishment and operation of municipal power, heat and light works."

The Act directed that in the event of such Commission being appointed, the Commissioners should report to the appointing municipalities full particulars, among other things, of the power consumed and required in the districts concerned, the capital and operating costs of the proposed works, and the rates that would require to be charged consumers of power and light.

The Commission was also expressly charged with the duty of determining "the proportion in which each of the said municipalities should contribute to, or become liable for, the cost of the proposed works."

The Act further authorized the Councils of the participating municipalities to cause the publication of the Commissioners' report for the information of the ratepayers, and directed that in the event of the report being favorably considered by the said councils, the question of carrying out the proposed enterprise should be submitted by by-law to the vote of the duly qualified electors.

Under the provisions of the said Act, the municipalities of Toronto, London, Brantford, Stratford, Woodstock, Ingersoll and Guelph appointed a Commission consisting of:—

E. W. B. Snider, Esq., of Waterloo,
P. W. Ellis, Esq., of Toronto,
W. F. Cockshutt, Esq., M.P., of Brantford,
The Hon. Adam Beck, M.P.P., of London, and
R A. Fessenden, Esq., Electrical Engineer, of Washington, D.C.,

to carry out the proposed enquiry, and, upon the conclusion thereof, the publication of the within Report was duly authorized by the Municipalities in question. The Commissioners, with the exception of the technical member, Mr. R. A. Fessenden, served without remuneration, while the remuneration paid Mr. Fessenden was merely nominal. Messrs. Ross & Holgate, of Montreal, the eminent electrical and hydraulic engineers, were appointed by the Commissioners to investigate and report upon the engineering aspects of the whole question.

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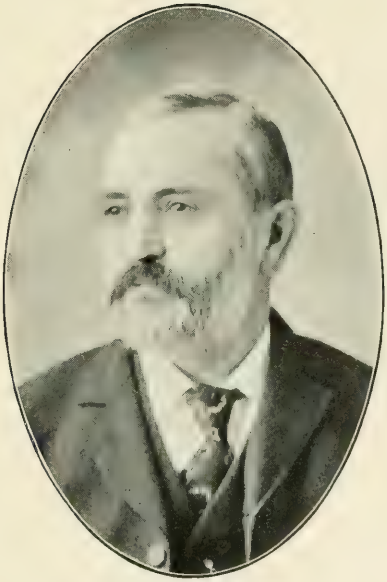


E. W. B. SNIDER, Esq.
Waterloo, Ont., Chairman

Toronto, March 28th, 1906.

To the Mayors
and the Municipal Councils
of the Corporations of Toronto, London, Brantford,
Stratford, Woodstock, Ingersoll and Guelph.

Gentlemen:—

The undersigned—your Commissioners, duly appointed to enquire into the question of a municipal development of power at Niagara Falls and to report thereon in accordance with the requirements of the Municipal Power Works Act (Chap. 25 S. O. 3 Ed. VII.)—have now completed their investigation, and beg to submit the results thereof, as follows:—

Consulting Engineers:

Messrs. Ross & Holgate, hydraulic and electrical engineers, of Montreal, were retained in this matter, and their fully detailed report to your Commissioners is appended hereto.

Power Requirements:

From the detailed report referred to, the power requirements are summarized as follows:—

Total present consumption of the 7 municipalities above mentioned	73,631 H.P.
Total estimated consumption of the 7 municipalities above mentioned two years' hence	87,883 H.P.
Net present consumption of the 7 municipalities above mentioned	55,325 H.P.
Approximate present consumption of 11 additional municipalities as undernoted	25,800 H.P.

In connection with the above it is to be noted:—

1st.—That the estimated increase in power consumption two years' hence is limited to the anticipated increased demand of existing consumers. No allowance has been made for additional demands that will arise in connection with inter-urban electric traction development, nor for the probable electrification of steam railroads.

2nd.—The present net consumption of the seven municipalities directly represented herein covers the quantity of power which—subject to satisfactory prices and existing contracts—an operating commission should, within a reasonable time after the completion of the proposed works, secure supply contracts for. That is to say, that deduction has been made from the gross consumption to cover all power, which, because of special local conditions, is regarded as being beyond the reach of municipal competition.

3rd.—In carrying out any transmission scheme appropriate to the needs of the seven municipalities represented herein, it becomes possible to furnish power under very advantageous conditions to certain other municipalities, namely:—Hamilton, Dundas and Paris, which are in the direct route of transmission; St. Thomas, which is within convenient distance of London; Galt, Hespeler, Preston, Berlin and Waterloo, which are within convenient distance of Guelph; and St. Mary's and Mitchell, which are within convenient distance of Stratford. The operating commission could, because of transmission conditions, deliver to municipal or independent distributing companies in these places the power required by them at very attractive prices, while at the same time such additional deliveries would reduce the cost of power required by the seven principal municipalities. The requirements, therefore, of these eleven additional municipalities were approximated at 25,800 H.P., as given above; hence the net requirements of the seven municipalities directly represented by your Commissioners, plus the approximate requirements of the eleven municipalities aforementioned, amount to 81,125 H.P. The municipalities included in the subsidiary group are limited to those having a population of 2,000 or over.

Making allowance, however, for the Operating Commission securing its contracts by degrees, your Commissioners have had estimates prepared of the cost of a development capable of supplying 100,000 H.P., but equipped for the supply of:—

1st.—30,000 H.P., being approximately one-half the present net requirements of the seven principal municipalities .

2nd.—60,000 H.P., representing approximately the total net requirements of the said seven municipalities, and

3rd.—100,000 H.P., representing the supply of the net requirements of the eighteen municipalities aforementioned, with a margin for growth of demand.

Capital Costs:

The capital costs * of the development, transmission and distribution of the three amounts of power indicated, including interest and sinking fund for construction period, have been estimated and apportioned between the participating municipalities as follows:—

	Cost of 30,000 H.P.	Cost of 60,000 H.P.	Cost of 100,000 H.P.	
Toronto	$4,323,096	$6,265,424	$6,216,137	
London	847,119	1,095,356	945,185	
Brantford	429,152	571,097	509,248	
Guelph	317,441	425,386	377,821	
Stratford	329,923	431,018	368,154	
Woodstock	216,226	278,939	244,589	
Ingersoll	221,672	287,391	249,754	
Hamilton	....	....	1,163,812	Subject to distribution cost.
St. Thomas	....	....	399,438	
Paris	....	....	123,322	
Dundas	....	....	66,359	
Mitchell	....	....	97,847	
St. Mary's	....	....	130,136	
Berlin	....	....	426,393	
Waterloo	....	....	189,628	
Preston	....	....	106,243	
Hespeler	....	....	48,095	
Galt	....	....	246,939	
Total	$6,684,629	$9,354,611	$11,909,100	

*N.B.—These costs are according to engineers' specifications.

It is, however, to be noted:—

1st.—That the costs of the 30,000 H.P. and the 60,000 H.P. developments include the complete transmission and distribution plants required to serve the seven municipalities concerned.

2nd.—That the cost of the 100,000 H.P. development includes the complete transmission and distribution plants required to serve the seven principal municipalities; but it includes only the development and transmission plant outlay required in connection with the eleven subsidiary municipalities, the distributing plants required being excluded from consideration.

3rd.—That the calculation of the approximate requirements of the eleven subsidiary municipalities and the estimate of the additional capital cost involved in meeting these needs at the municipal sub-station terminals represent a purely voluntary work of the engineers—not called for by your Commissioners. This cost, therefore, is submitted as additional information. The project it covers represents merely one mode of reducing the cost of power to the municipalities directly represented by your Commissioners, while at the same time it undoubtedly confers great benefits upon the additional municipalities which would be served by it. This will be seen clearly in the later references to operating costs.

4th.—That, if the said eleven municipalities were to join those represented by your Commissioners for the purpose of carrying out a complete consolidated undertaking, beginning at Niagara Falls and terminating at the consumers' premises in each of the eighteen municipalities, the cost involved in the eleven additional distributing plants would require to be ascertained and added to the figures given above.

5th.—That the site at Niagara Falls, which is recommended for the purpose of carrying out the above development is marked No. 4 on map No. 1 annexed hereto, and the routes of the proposed transmission lines are shown on map No. 2 annexed hereto. For a technical description of the complete undertaking reference is made to the engineers' report annexed.

Annual Expenses:

The estimated total annual expenses of all kinds, including water rental, repairs, renewals, contingencies, interest and sinking fund, but excluding taxes for the reason that the undertaking is expressly exempted from taxation, are as follows:—

	30,000 H.P.	60,000 H.P.	100,000 H.P.
Interest and sinking fund	$371,163	$519,425	$661,266
All other charges	488,447	619,126	752,368
Total	$859,610	$1,138,551	$1,413,634

It is to be noted that:—

1st.—Under the instructions of your Commissioners, and for reasons hereinafter stated, interest has been computed at the rate of 4½ per cent. per annum, and the sinking fund charge has been computed upon the basis of retiring in forty years the whole bond issue required to pay the original capital cost, but upon the assumption that the investments thereof shall be made at a maximum rate of 4 per cent. per annum.

2nd.—The above estimate of expenses does not include anything for distribution in the eleven subsidiary municipalities, for the reason already stated in the explanation of capital costs.

Service Rates:

The rates that it would be necessary to charge consumers in order to make the undertaking self-sustaining on the three developments indicated, are as undernoted.

These rates are computed on a twenty-four hour basis. The variations of price required to meet the varying duration of service demanded by consumers must be settled by the Operating Commissioners with regard to the local conditions of demand, etc. These will vary in each municipality, and, as they will remain unknown until the supply contracts are entered into, they cannot be intelligently approximated.

I.—Motor service per H.P. per annum: 24-hour service at consumers' premises.

Municipality.	30,000 H.P.	60,000 H.P.	100,000 H.P
Toronto	$21.97	$15.73	$14.60
London	53.07	23.87	20.34
Brantford	30.02	17.93	15.57
Guelph	27.68	18.26	16.70
Stratford	33.67	21.45	19.42
Woodstock	34.48	21.05	17.53
Ingersoll	33.96	21.61	17.99

II.—Arc lighting: Cost per lamp per year.

Municipality.	30,000 H.P.	60,000 H.P.	100,000 H.P.
Toronto	$42.02	$37.61	$36.48
London	54.08	44.89	41.36
Brantford	49.73	42.91	40.55
Guelph	47.84	40.69	39.13
Stratford	56.83	47.23	45.20
Woodstock	56.16	48.16	44.64
Ingersoll	72.58	64.02	60.40

III.—Incandescent lighting: Cost per K. W. H.

Municipality.	30,000 H.P.	60,000 H.P.	100,000 H.P.
Toronto	$.0741	$.0640	$.0614
London	.1150	.0925	.0839
Brantford	.0945	.0778	.0720
Guelph	.1140	.0965	.0926
Stratford	.1218	.0983	.0934
Woodstock	.1307	.1091	.0995
Ingersoll	.1321	.1112	.1023

IV.—The surplus power generated and transmitted with the object of serving the subsidiary municipalities would cost at the municipal sub-station switchboards—that is, without any allowance for the local distributing cost—as follows:—

Municipality.	Cost per H.P. per annum at municipal switchboard.
Hamilton	$ 8.89
St. Thomas	15.09
Paris	12.19
Dundas	11.13
Mitchell	24.62
St. Mary's	19.67
Berlin	12.68
Waterloo	14.55
Preston	16.00
Hespeler	20.06
Galt	15.85

Present Costs of Steam Power and Lighting Services:

The average costs of steam engine power developed for ten-hour day industrial use under the general conditions prevailing in the municipalities your Commissioners represent have been investigated and computed as undernoted. The costs for a twenty--four-hour service required in public service plants vary with the peculiar conditions of each undertaking, but they are, of course, much higher than those given below. The arc and incandescent lighting rates are reported by the engineers as varying considerably, but the undernoted scale is submitted by them as a fair approximation.

Average steam power costs: Ten-hour service.

Indicated horse-power of plant	10 H.P.	$111.50
" " " "	25 H.P.	78.00
" " " "	50 H.P.	57.50
" " " "	75 H.P.	53.50
" " " "	100 H.P.	48.00
" " " "	150 H.P.	40.60
" " " "	250 H.P.	32.00
" " " "	500 H.P.	27.80
" " " "	750 H.P.	24.00

These prices are based on a 75 per cent. load, which corresponds with average existing conditions.

Approximate Lighting Rates:

Municipality.		Incandescent per K.W. hour.	Arc lamp per year.
Toronto		8c.	$69.35
London		9c.	83.95
*Brantford		10c.	55.00
*Guelph	Sliding discount renders difficult any attempt at accurate statement of rates.	from 10c. to 15c.	65.00
*Stratford			65.00
Woodstock			60.00
Ingersoll			60.00

Savings Effected Under a Municipal Development:

The savings that would be realized under a municipal development have been carefully estimated. The present net annual demand for power by the seven municipalities your Commissioners represent, which ought, under a municipal development, to be supplied by the Operating Commission, amounts to 55,325 H.P. This includes arc lighting, incandescent lighting, manufacturing, pumping, traction and other public service requirements. The savings, which represent the difference between existing costs and the costs that would follow a 100,000 H.P. municipal development are as follows:—

Estimated savings on	Amount of same	Representing a reduction of existing costs of
Arc light service	$78,257.00	45%
Incandescent light service	92,537.00	21%
Industrial motive power	769,531.00	69%
Other motive power	924,233.00	77%
Annual savings	$1,864,558.00	63.5%=average %

---

*Probably midnight schedule.

Now it is to be observed:—

1st.—That these savings are—subject to the condition next noted—the minimum that may be expected. The estimates have been made on the most conservative basis. The existing commercial costs have been estimated on a low, and the proposed municipal costs on a high basis.

2nd.—That a certain liquidation, however, of existing plant and equipment and the replacement thereof by motors to suit the changed conditions will be necessary. These changes will involve a certain loss of capital. The exact amount cannot be estimated with absolute accuracy. No two places are the same, and each individual liquidation will be affected by the manner in, and the local conditions under, which it is accomplished. It is also highly important to remember that the true loss involved is not the difference between the book values of the properties liquidated and the liquidation proceeds, but the difference between the intrinsic value and the liquidation proceeds of the properties in question. Your Commissioners have had a careful and conservative estimate made of the approximate loss that may arise in connection with the necessary liquidation, and the additional capital expenditure that will be necessitated by the motor replacements. After adding 50 per cent. to the engineers' estimates—which are themselves conservative—the amount is less than $4,000,000. Now if the capital sum of $37,291,160 were invested in 5 per cent. per annum interest-bearing securities on behalf of the power consumers in question, the annual income they would collectively derive therefrom would amount to exactly the savings above estimated, namely, $1,864,558. These savings, therefore, represent a capital value of over $37,000,000, from which, if the $4,000,000 above mentioned is subtracted to cover the loss and cost of capital changes involved, a net saving of the capital value of $33,000,000 remains.

3rd.—That the saving in question is real, not imaginary. There is no difference to the immediate beneficiary between $100 per annum saved in expenditure and $100 per annum added to income. In either event he is $100 per annum better off. If $100 per annum be saved in expenditure and invested in a given security, that security is just as real and genuine as though it represented the investment of an equal addition to income. The capital value of $33,000,000 above estimated represents, therefore, a real and substantial addition to the wealth of the power and light consumers. It is to be emphasized that this is not a mere abstract mathematical proposition. It is a substantial fact, which is only dependent for realization upon the decision of the municipalities and the retention of the requisite technical and business ability to give effect to that decision. Mathematics are employed only for the purpose of presenting an adequate conception of the value involved.

4th.—That the savings indicated accrue exclusively *to the consumers of the seven municipalities your Commissioners represent.* They do not, however, represent the savings on all the power consumed in these municipalities, but only on that part of it which it is believed the Operating Commission may with reasonable ease secure contracts for. No allowance has been made in the above estimate for the savings accruing to the consumers of the eleven subsidiary municipalities, whose needs in some measure the 100,000 H.P. development will supply. If, however, a general perception of the great commercial value of a municipal development should manifest itself, and in consequence an enterprise were carried out suited to the needs of all those in this Province who might and ought to, participate therein, the project would go far beyond the limits of that which is herein dealt with, and as a further consequence the costs would be still further reduced and the aggregate saving to the participants would reach colossal figures.

5th.—It is also important to remember that the municipal development prices above mentioned cover a twenty-four-hour service. Only a small proportion, however, of the public demand is for a twenty-four-hour service, and it becomes, therefore. an important question with every power supply company to make contracts which will enable it as far as possible to sell the whole of its power for the whole of the time available, that is, for twenty-four hours daily. For the purpose of illustrating this matter as clearly as possible in a non-technical fashion, let it be supposed that for a given development of 1,000 H.P. there should be a demand as follows:—

For a 24-hour service	250 H.P.
For a 10-hour service, from 7 a.m. to 6 p.m.	750 H.P.
For an all night service, from 6 p.m. to 7 a.m.	750 H.P.
	1,750 H.P.

It is clear that if demands of the above character were made on the plant in question the effect would be that of greatly increasing its earnings. Suppose, for further illustration, that the standing cost of maintaining a twenty-four-hour service was $20 per H.P. per annum. The yearly earnings of a 1,000 H.P. plant at $20 per H.P. per annum would amount to $20,000, but if, under the purely illustrative conditions mentioned above, the twenty-four-hour consumers were charged $20 per H.P. per annum, and the ten-hour daily, and the all-night consumers were charged respectively $15 per H.P. per annum, the yearly earnings of the plant would be as follows:—

24-hour consumers, 250 H.P. at $20	$ 5,000
10-hour daily consumers, 750 H.P. at $15	11,250
All-night consumers, 750 H.P. at $15	11,250
Total	$27,500

Or 37½ per cent. in excess of the first named amount. The process of regulating the sale of power with the view of insuring that the demands upon a plant shall be made as uniform as possible for the full period of twenty-four hours in each day is called in technical language "flattening the load curve." The full significance and meaning of this technical phrase will be made perfectly clear by reference to the diagramatic explanation given by Professor Fessenden in his brochure annexed hereto. Now it is to be carefully noted that the estimated income of the proposed municipal power development does not include any loading or allowance for the additional income that will be realized under practical working conditions from the "flattening of the load curve." It is, however, obvious that the power consumed at night by arc and incandescent lighting is available for sale during the day, and, reciprocally, whatever power is consumed during the day by industrial and other undertakings is available for sale during the night. To whatever extent this process is realized the earnings of the undertaking will be increased. Now these increases, which it is conceivable may run into very substantial figures, may be utilized in any of the following ways, namely:—

1st.—To reduce the motor and lighting rates already indicated.

2nd.—To pay for any improved installations that may be necessitated by the progress of invention.

3rd.—To increase the sinking fund and to retire more rapidly the original bond issue.

But to whatever purpose such additional income may be applied it is clear that it constitutes a financial saving distinct from and additional to that which is estimated above. It will also be carefully noted that the 37½ per cent. excess earnings from this source which is worked out in the illustration given above is only illustrative. It is not intended to afford any index to the actual percentage of additional income that may be expected under the practical conditions that will be encountered.

6th.—It may not be out of place to identify clearly the beneficiaries of the aforesaid savings. It is a very simple task. The direct consumers of light and power are divisible into the following classes:—

(1) Municipal corporations.

(2) Trading and other corporations having gain for their object.

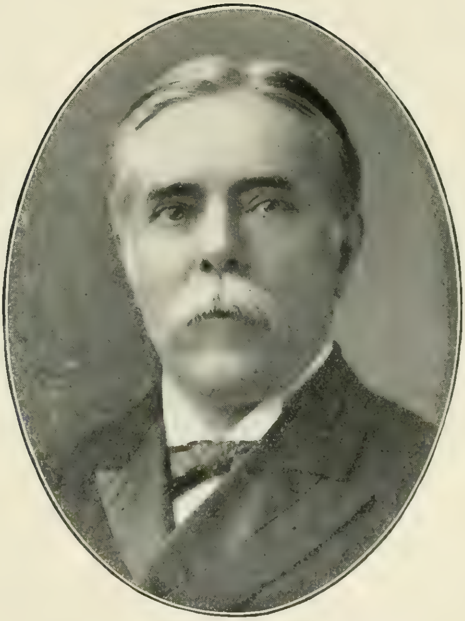
(3) Unincorporated business firms.

(4) Private householders.

(5) Incorporated and unincorporated associations not having gain for their object.

Now it is perfectly clear that any savings accruing to municipal corporations will take expression in reduced demands on the ratepayers. Incorporated and unincorporated associations whose object is not that of gain, will, to the extent of the benefits they derive from reduced charges, relieve their supporters accordingly; or in the alternative, their various religious, educational, philanthropic and social activities will be stimulated to the good or ill of society as the case may be. Private householders will clearly and directly reap the benefits of any reduction in the burden of existing rates. In the case of all corporations having gain for their object, the reduced charges will appear in increased profits for the shareholders, and in the case of unincorporated business firms the same effect will be produced for the proprietors. Under, however, the laws of competition and industrial development any permanent lowering of the cost of production and distribution tends also to take partial expression in reduced prices of commodities. This process, however, merely transfers a part of the benefit to society at large. It is, however, to be remembered that in the increased demand for commodities, which is always created by a permanent lowering of costs, the manufacturer, merchant or other distributing agent finds ample compensation for sharing with consumers at large the advantages of any such reduction. The additional trade created thereby yields a profit in excess of that which has been distributed to the customer. It is, therefore, clear that each class of society indicated will receive directly its full share of the additional wealth so created, while it will also participate in the indirect gains proceeding therefrom that enure to the benefit of society as a whole.

7th.—The effect on industrial development of the savings in question is, however, so important that it is worthy of special consideration. The municipalities represented by your Commissioners are pre-eminently manufacturing and industrial communities. They are equipped by nature to excel. They enjoy a high degree of proficiency in the manufacturing arts. The overflow of their aggressive and self-reliant enterprise has pushed their products into many lands. The barriers of cheaper labor and other natural conditions, which might have kept them out, have been overcome. From the great economic leverage that Niagara power—unloaded by corporation tribute—will give, an incalculable stimulus to the productive and competitive efficiency and enterprise of their manufacturers will be derived. These economic conditions will not only, in obedience to a natural law, beget an increasing activity, but they will also attract to the district the enterprise of others. Just as virgin pine on the banks of carrying waters attracts the lumberman, and as the choicest fishing grounds attract the fisherman, so will unique manufacturing conditions attract the manufacturer. As a result, therefore, of such a development as is herein considered, a great stimulus to manufacturing activity may confidently be expected. If, however, all the municipalities that are capable of being efficiently served by a Niagara Falls development were to combine and carry out an undertaking corresponding to their needs and prospects, it would exercise an influence upon their future that cannot be estimated, and that the past industrial history of Ontario affords no parallel to.



P. W. ELLIS, Esq., Toronto, Ont.
Vice-Chairman and Treasurer

Alternative Developments:

The capital and operating costs given above are based as stated upon a Niagara development at site 4, as shown on map No. 1, annexed. This is the site which is recommended both by Ross and Holgate, the consulting engineers, and by Professor Fessenden, the technical member of the Commission. Your Commissioners, however, understand that a dispute has arisen between the Niagara Falls Park and River Railway Company and the Park Commissioners as to the water rights of the former, whose intake is in the immediate vicinity of the proposed site No. 4. They further understand that it is, or has been, alleged that if a development at site 4 were carried out on the scale herein recommended, it would seriously interfere with the rights claimed by the Niagara Falls Park and River Railway Company. This claim, however, has not been proven, and your Commissioners feel that to abandon the idea of developing site 4 merely because of the unadmitted and unproved claims of an existing company would hardly be consistent with their duty in the premises. The Park Commissioners have also quite recently intimated that they would be indisposed for scenic reasons to recommend that any development at site 4 be allowed. As, however, the site in question has been recommended by Mr. Isham Randolph, C.E., of Chicago, and has been held out in the published reports of the Park Commissioners as available for development, and as the plans contemplated hereunder include a subterranean power-house, which might be made to add to, rather than detract from, the beauty of the Park, your Commissioners feel that probably this difficulty could be overcome by friendly conference with the Park Commissioners, who have shown every desire to facilitate the enquiry herein. Mr. J. D. Langmuir, the President of the Park Commissioners, has extended every courtesy and assistance to the representatives of your Commissioners—a fact which they desire to publicly record and acknowledge. In view, however, of these conditions it has been deemed advisable to ascertain the additional costs involved in carrying out a substitutionary development. These have, therefore, been worked out in detail to show the capital and operating costs following a development at site 3, as marked on said map No. 1, and will be found in appendix "A" annexed hereto. The additional capital expenditure involved in developing sites numbered 2 and 1 on said Map No. 1, have also been computed and are submitted in said Appendix "A." (N.B.—Mr. Randolph was retained by the Park Commissioners.)

Financial Provisions:

Sections 34 to 42 inclusive of the Municipal Power Works Act deal with the manner of financing the undertaking. The principal directions, apart from those relating to forms of procedure, are as follows:—

1st.—The municipal corporations concerned are authorized to issue debentures to the estimated amount of their respective shares of the capital cost, and deliver the same to a trustee to be appointed in the manner duly set forth by the Act. The debentures so issued are to be sold in accordance with the terms of an agreement to be entered into between the municipal corporations, the construction commission and the trustee, and the proceeds of the sale or sales are to be paid over to the construction commissioners in the manner duly prescribed by the Act.

2nd.—The construction commissioners are authorized to issue bonds secured upon the total assets of the undertaking to the amount of the proceeds of the municipal debentures aforementioned. These bonds are to be delivered to, and held by, the trustee in trust for the municipal corporations on the terms contained in the agreement aforementioned, but subject to the express trusts governing the collection and disposition of interest, sinking fund and other matters as are set forth in the Act.

3rd.—In the event of the capital cost of the completed works exceeding in amount the proceeds of the bonds issued in connection therewith the Commissioners are authorized with the approval of the Chief Justice of Ontario for the time being to issue "special bonds" secured by a first lien on the whole property of the undertaking, and carrying "a preference over the other bonds" to meet the amount of such deficit. Further, if it should become necessary or advisable at any time to extend or improve the works or any part thereof, and provided that funds are not otherwise available to meet the cost of such extensions or improvements, the Commissioners may, with the approval of the Chief Justice of Ontario raise from time to time the amount necessary by the issue and sale of "special bonds" carrying priority over the other bonds as aforesaid.

Your Commissioners would be remiss in their duty if they did not point out that the borrowing of the large sum of money necessary to carry out the proposed undertaking—ranging from $7,000,000 to $12,000,000 on the development of site 4, according to the scale adopted—is liable to put some strain on the credit of the municipalities concerned. The credit of the municipalities represented herein stands, and deservedly stands high. Nevertheless the heavy addition to existing debt that the necessary borrowings will involve, and the fact that the enterprise itself is a new departure for Ontario municipalities, will be closely scrutinized and considered by investors. As the immediate benefits and the ultimate fruits of the undertaking are realized, caution will give place to confidence, and if the undertaking should prove highly successful, it may ultimately become a means of raising rather than straining municipal credit. Meantime, however, the probabilities have to be considered, and for the purpose of placing the municipalities upon the strongest possible footing against the necessary loan flotation, your Commissioners recommend that:—

1st.—The municipal debentures to be issued should be secured by a specific first charge upon the bonds to be issued by the Construction Commission or upon the property itself. In addition to this, they should, of course, carry the full covenant of the issuing municipalities. There will be an appreciable difference in the price they will realize if this recommendation be accepted.

2nd.—Application be made to the Legislature to allow the municipalities and the Construction Commission to vary,—as may be deemed advisable at the time,—the provisions of the Act in regard to the issue of "special bonds." The right to issue "special bonds" from time to time as required without any limitation as to amount, when such bonds take priority over the previously issued construction bonds, is liable to interfere with the marketability of the construction issue.

Legal Position:

Section 52 of the Municipal Power Works Act expressly states that "Nothing in this Act contained shall be deemed . . . to authorize the Commissioners to supply power, heat or light in contravention" of the "provisions contained in sections 566 to 568 inclusive of the Municipal Act." Section 566 of the Municipal Act permits certain municipal corporations therein described to construct works for lighting the public streets, but only upon condition that an offer be first made in the prescribed manner to purchase the works and property of any existing electric light company "that has supplied or shall supply . . . electric light for street lighting in the municipality." Your Commissioners applied to the municipalities they represent for copies of all existing contracts with electric light companies for the purpose of ascertaining the municipal corporation rights and obligations thereunder. They received in reply copies of the contracts and governing by-laws from all the municipalities to which they applied with the exception of Ingersoll. The said contracts and by-laws were submitted to Counsel, who advised that before the municipalities could proceed to carry out the proposed undertaking, they would require to make offers to buy out the existing electric light companies in Toronto, London and Brantford. The position of Ingersoll is uncertain on account of lack of information. Upon this view of the state of the law your Commissioners instructed their engineers to value the assets of the lighting companies concerned upon the principles which the arbitrators are directed by the Municipal Act to observe in making their awards. The Brantford Electric and Operating Company, Limited, freely and courteously gave access to its premises, but the Toronto Electric Light Company and the London Electric Company refused access to their plants. As your Commissioners had no power to force admission, they had, of necessity, to restrict themselves to estimating the cost of an entirely new and independent undertaking. Their original intention was to report upon the cost of an undertaking based upon the acquisition (under the section of the Municipal Act above mentioned) of the plants of the companies in question, in addition to that of an entirely new undertaking. This course was, however, rendered impossible by the facts above mentioned. It is, therefore, to be most carefully observed that section 52 of the Municipal Power Works Act, and sections 566 to 568 of the Municipal Act (the latter being popularily known as the Conmee Act) will, as they stand at present, interfere with the carrying out of the new undertaking hereby reported on.

It may also be stated that section 11 of the Municipal Power Works Act may possibly require revision. If the construction of the proposed works should increase the debt of any participating municipality beyond the amount authorized by law at present, such municipality would be debarred from borrowing the excess amount required unless said section 11 were revised. The participating municipalities should be given power to borrow the amount necessary for the purpose of carrying out the proposed works in addition to the borrowing powers they presently enjoy.

Preservation of Falls:

Considerable public agitation has recently been manifested in the United States on the question of preserving the natural beauty of Niagara Falls. The object in view is that of preserving scenic effect by limiting the amount of water to be taken from the river above the Falls for power purposes, and thereby preventing any material diminution in the quantity of water discharged over the Falls. Mr. Griggs (a former Attorney-General of the American Federal Government) gave an opinion on the 31st of January this year to the Merchants' Association of New York on the question of the "Jurisdiction and power of the United States over the use of the waters of Niagara River above and below the Falls of Niagara at points where it is contemplated to take water from the river for power or commercial purposes." This opinion, along with other related documents was made public a few weeks ago in a committee report of the United States Senate, and, as throwing an interesting and reliable light upon the probable outcome of the agitation, the following excerpt may be quoted:—

"Whatever jurisdiction the State of New York has over the waters of the river and their use is subject and subordinate to the power of the National Government in two respects:—

"1st.—With respect to navigation, as to which the laws of Congress are supreme.

"2nd.—As to the subject of boundary between this nation and Canada in respect to which the United States and Great Britain have the right, by treaty stipulation, to impose such conditions and regulations upon the use of the river and its waters as they deem mutually proper. A treaty duly negotiated between these two powers and ratified by the Senate of the United States would be the supreme law of the land, and if in such treaty it were provided that no such use of the waters as is contemplated should be hereafter made, and this regulation were enforced by Act of Congress, the treaty and the legislation would be valid, the rights of the State of New York and all private riparian owners to the contrary notwithstanding."

With the question of sovereign jurisdiction over the affected waters your Commissioners are not concerned. It may on the Canadian side be vested in the Dominion Government or it may be vested in the Ontario Government. The important question to be borne in mind is, that against the contingency of limiting, whether by international treaty or legislation, the quantity of water which may be taken and used for power purposes, representations should be made to the Governments concerned that all the water necessary to supply the power and lighting needs of the municipalities dependent for such on Niagara Falls should be reserved for their use.

Special Articles by Professor Fessenden:

Professor Fessenden, the technical member of the Commission, has prepared for publication with this report some brief but interesting and valuable observations on various phases of the power question. They will be found annexed hereto. With reference to his article on the municipal operation of lighting plants, it must be noted that in this particular case ample provision is made for any abnormal expenditure that may be necessitated by the progress of invention. The operating costs already quoted include a sinking fund loading that will retire the whole of the original or construction issue of bonds in forty years. No large subsequent replacement of workable equipment would be sanctioned, or indeed called for, unless substantial economies in the operating costs should follow. But in the latter event, the economies in question could be entirely devoted to the redemption of the replacement bonds, if such course were deemed wise or necessary. It is also to be remembered that all excess earnings that will be derived from the regulation of the load curve can, if necessary, be made available for any abnormal expenditure. Further, in any event, the construction corporation has a statutory right to issue improvement bonds for any necessary extensions; and as the quantity of power sold should increase yearly, a proportionate reduction in the cost per unit of power may be expected yearly; this leaves room for the retirement of improvement bond issues by the automatic operation of the sinking fund, without either entrenching upon special profits or raising the scale of prices.

Reliability of Costs Submitted:

Messrs. Ross and Holgate, the consulting engineers herein, have made what they consider ample allowance for all contingencies, in respect of both capital and operating costs. Their work has been done in the most satisfactory way, with the greatest care, and, in addition to purely actuarial checks, it has been fully and critically examined and confirmed by Professor Fessenden. An estimate, of course, is always, and necessarily, subject to the risk that unanticipated conditions may be encountered in the actual physical development. It is not possible to eliminate this risk. All known and probable conditions, and the experience of the companies already established have, however, been taken into consideration, with the net result that the engineers believe the costs are over rather than under stated. Your Commissioners have every confidence in the capacity and judgment of their advisers, and they, therefore, believe that the event will vindicate the estimate.

Conditions of Success:

There is no dispute as to the existence of the power or the demand for it. There is no doubt as to the supply of technical and practical skill necessary to establish and operate the works required. There is no question as to the financial ability of the municipalities to carry out the undertaking. The one fundamental condition of success is that the constructing and operating commission shall be composed of highly capable business men, whose supreme and constant aim shall be that of realizing the highest degree of efficiency in the various services. Operated thus as a purely business institution, and absolutely divorced from politics, your Commissioners have every confidence that the future of the enterprise will prove increasingly successful.

Public Criticism:

No municipal project of this magnitude can escape criticism. It will proceed chiefly from two sources, namely—from those who on principle are opposed to such extensions of municipal activity, and from those whose interests are liable to be injuriously affected by it. Criticism proceeding from the latter source may, and doubtless much of it will, be founded on conviction; but part of it is liable to be colored by considerations of self-interest. That of the first-named order is educative in its purpose and effect. Whether it directly expounds, or merely provokes the exposition of, sound public policy, the effect is a clarification and strengthening of the public mind. For this reason, it is always to be welcomed. Criticism, however, of the order last mentioned is, alike in its motive and object, limited to purely destructive purposes. Its tone and method may vary, but its object remains the same. Now the advent of power and lighting rates, such as are indicated herein, will make such inroads upon the available market for power that opposition is naturally and necessarily assured. Nor can any exception be taken to the fact that it will be offered. It is the outcome of the natural sense of self-preservation. It has to be met and it can be met. While no good purpose would be served by attempting to anticipate detailed criticism, it may not be out of place to note that neither a contradiction of the facts reported, nor the opposing opinions of eminent experts, nor lofty academic observations upon the impropriety of such municipal ventures will either change the facts or diminish the benefits they are capable of yielding. The basal fact that power and light can be supplied under a municipal development, properly carried out—under engineering conditions equal to those of its commercial competitors—at prices beyond the reach of permanent commercial competition, is not open to argument. Neither existing nor future differences between electric and steam-power commercial rates, nor Government control of electric-power rates, nor a sliding scale of rates, nor Government expropriation of existing companies, nor any other device, can alter this basal fact or destroy the public benefits proceeding from it. The rates chargeable by the undertaking herein reported on, include provision for 4½ per cent. interest being paid on the bonds and for their redemption at maturity. No other charges except for the necessary maintenance and operation are incurred. Competing companies have to pay considerably higher interest rates on their bonded debt, and in addition they have large issues of capital stock on which dividends have to be earned. Whether rates be fixed by the companies voluntarily or under Government regulation, regard must be paid to these conditions and the rates loaded accordingly. No criticism directed at detached isolated, facts or figures will alter these broad, underlying conditions from which the general public will derive benefits otherwise unattainable.

Municipal Trading:

Municipal administration is a branch of civil government, and the proposed undertaking may be regarded as a development of municipal trading. The intrusion of government into trading spheres, and, indeed, the extension of its functions beyond the smallest minimum possible, has occasioned much debate and received much condemnation. Perhaps the weightiest reason ever urged in favor of limiting its functions was that of John Stuart Mill, who saw in every extension of government agency only the deprivation of the people of opportunities for genuine training in the real business of life. Without the opportunity, development is impossible, and a stunted growth and civilization was, therefore, in his view the penalty that would be exacted for neglecting this principle. A great change, however, has taken place in the complex organization of society in the last half century, and under our modern democratic system of government there is not the cleavage between ruler and ruled corresponding to that which Mill contemplated. Indeed the extension of municipal trading or the municipal operation of public services may be regarded as an evidence of the fitness of the people in, rather than as a certain means of unfitting them for, the business of life. Such branches of civic enterprise represent the voluntary efforts of society to work out a more efficient civilization, and in their organization and operation they afford the very opportunity for development that Mill desired. It has, of course, been alleged that such extensions of municipal activity constitute a check to industrial development. Without, however, surveying the whole field, it is tolerably clear that this particular enterprise constitutes an industrial development of the first magnitude. And inasmuch as it is not proposed to monopolize the waters of the continent or even the Province, there is an ample field left for independent commercial progress and for individual development, even if the latter were impossible under state or municipal institutions.

All other objections to such enterprises rest on grounds of expediency. The growth of municipal debt, inferior management, consequent loss to the ratepayers and other objections of like order comprise the whole indictment. These, of course, can only be considered in their particular applications. In this special enterprise there is no reason why any of these calamities should occur. It is proposed to operate the undertaking by a special and independent board of commissioners, and it has not been predestined that the most incapable men of the community shall be so appointed. The municipalization of certain public services that lend themselves readily to such control seems to be an increasing tendency of the times, despite the fact that numerous failures have occurred. It may not be out of place to recall the fact that while the failures have been heralded and held up as warnings, there have been some conspicuous success. The city of Glasgow, as far back as 1860, completed its great scheme of civic water-works, in regard to which every conceivable prediction of disaster had been made. Of the commercial success achieved, not to speak of the great and beneficient effects on the public health and upon the industrial interests of the city, it is almost impossible to speak too highly.

Similarly the Gas Supply, the Electric Light and Power Supply, and the Tramway Services have been taken over with signal success. The price of gas was reduced from 4s. 7d. in 1870 to 2s. 1d. in 1904 per 1,000 feet. The Electric Power and Light Department was acquired in 1890 for the capital price of £13,000. The annual gross revenue has increased until for the year ending 31st May, 1905, it amounted to nearly two hundred thousand pounds sterling. The Tramways Department has been operated with conspicuous success, some criticism to the contrary notwithstanding. This success includes, not only an excellent service, but the most pleasing financial results. In 1894, 54,000,000 passengers were carried; in 1904-1905, 195,000,000 passengers were carried. When the corporation system was commenced the fares were reduced, and from time to time as the revenue permitted, further reductions have been made. The governing principle in these services is to make them separately water-tight and self-sustaining, applying to reduction of cost or improvement of service the profits of each undertaking separately. In 1903 the Tramway Service net income, after providing for maintenance and certain renewals, amounted to nearly £300,000, out of which provision was made for special depreciation, special renewals, interest and sinking funds and a balance of £25,000 donated to what is styled the "Common Good." It is also worthy of note that the committee of twenty-five representatives to whom the City Council has entrusted this large undertaking has not among its members, and never has had, one single member who could be called a tramway expert. Other illustrations might be given of the success that has attended municipal enterprises, but these will suffice. They are stated because encouragement is naturally derived from examples of success, just as discouragement and restraint follow examples of failure. Of the beneficent fruits of state works on a larger scale and under different political conditions many examples might be given. The great Nile Delta Barrage built about ten miles below Cairo, and which British engineers took seven or eight years to renovate, has had the effect of bringing into cultivation about one million acres of land, the annual yield of which is from £5,000,000 to £7,000,000. The Assuan dam, designed by Sir Wm. Willocks, raises the water level of the Nile 65 ft. above low level and stores from 1,000,000,000 to 1,200,000,000 tons of water, affecting the river for one hundred and forty miles back. This work irrigates one million acres of land and increases the value of the produce by about £2,500,000 annually. These facts are quoted as illustrating further the beneficent effects on human welfare that follow intelligent and well conceived state aid. The statement in advance of the fact, of the estimated results of any great work, is always received with a certain measure of doubt and scepticism, but the actual results that have been achieved in the municipal and larger state undertakings referred to above are greatly in excess of the original expectations. Your Commissioners do not hold the opinion that there is some radical inherent defect in Canadians as compared with others that will foredoom to failure a civic enterprise such as that under consideration.

There does not seem to be any legitimate ground for complaint on the part of existing power companies if the proposed development be carried out. Aid to railways, regulation and control of railway rates, Government construction and operation of railways, regulation and control of telephones and many kindred undertakings, have been sanctioned by public opinion, and the corporate undertakings affected by the proposal herein have been developed under these conditions and subject to these risks. In effect they operate no more harshly aganist existing corporate interests than existing commercial conditions and tendencies operate against private individuals. The private trader has had to risk his capital in competition with the highly organized and heavily capitalized department store of modern growth. The ordinary manufacturer risks his capital in competition with the great corporate combinations of the day. Individual enterprise was neither insured against these risks nor indemnified in respect of their consequences. If, in the development of industrial efficiency, the corporations in turn are exposed to some of the risks they have created for others, this seems to be merely a continuance of common experience. The industrial future of the Province is in question. The leverage arising from the proposed power, as has already been pointed out, is so great that in the keen competition of the present day it cannot be ignored. Moreover it is not proposed to monopolize the market. There is an ample field in the electrification of railways and the growth of the inter-urban electric railway systems of the future for the existing companies to operate in, and by wise and prudent management to conserve their capital.

Conclusion:

Your Commissioners believe that the industrial future of the communities that are capable of being supplied with electric power generated at Niagara Falls depends in very great measure upon the utilization of that power; and they strongly and unhesitatingly recommend that—whether or not expropriation of the lighting companies referred to becomes necessary—the proposed enterprise be taken up and pushed to completion. They are unanimously of opinion and they definitely recommend:—

1st.—That a municipal development of the type reported on herein be carried out on a scale suited to the needs of as many municipalities as are willing to join in the undertaking, and to that end they advise that all other municipalities capable of being served by a Niagara Falls development be furnished with copies of this report and be requested to join in the carrying out of the proposed enterprise.

2nd.—That in the event of other municipalities being unwilling to take up the matter, those directly represented herein, namely, Toronto, London, Brantford, Guelph, Stratford, Woodstock, and Ingersoll, carry out with all possible expedition a development of the 60,000 H.P. type reported on.

3rd.—That, subject to the approval of the construction engineers, the development be carried out at site 4, as shown on the illustrative map No. 1 annexed. This site is for development purposes, the best and cheapest within the park limits. This opinion appears to have been held by Mr. Randolph, C. E., of Chicago, who was retained by the Park Commissioners to report upon the available power sites. It has been confirmed by Messrs. Ross and Holgate, and ratified by Professor Fessenden, and they do not think that the interests of the municipalities should be sacrificed either to illusory fears that the beauty of the park would be impaired by the proposed development or to any dispute arising out of the contested claims of another company.

In the event of other municipalities being willing to join with those your Commissioners represent, for the purpose of carrying out a development corresponding to their needs, it would be well to make specific enquiry into the actual power conditions prevailing in such other municipalities, and at the same time to estimate the cost involved, including the distributing stations and plants, that would be required in connection therewith. By so doing the total cost of one consolidated scheme, beginning at Niagara Falls and terminating at consumers' premises within the participating municipalities, would be ascertained, and could be placed before the respective bodies of ratepayers for consideration. Your Commissioners have—by ascertaining and stating the facts herein reported, and by submitting the conclusions and recommendations that a careful study of the facts has led them to—discharged the duties they assumed, and they now leave the matter and its issues in the hands of the public they have had the honor of representing.

Respectfully submitted,

(Signed) E. W. B. Snider, Chairman.
P. W. Ellis,
W. F. Cockshutt,
A. Beck,
Reginald A. Fessenden.

APPENDIX "A."

Capital Costs and Operating Rates that Would Follow a Development at Site Marked No. 3 on Annexed Map, No. I.:

Capital Costs:

Municipality.	Cost of 30,000-H. P.	Cost of 60,000-H. P.	Cost of 100,000-H. P.
Toronto	$5,043,677	$6,982,362	$6,708,654
London	927,378	1,175,209	1,000,041
Brantford	486,100	627,757	548,172
Guelph	361,238	468,957	407,755
Stratford	365,748	466,661	392,639
Woodstock	239,689	302,283	260,635
Ingersoll	245,272	310,871	265,884
*Hamilton			1,315,251
*St. Thomas			432,622
*Paris			135,923
*Dundas			74,019
*Mitchell			102,798
*St. Mary's			138,367
*Berlin			463,157
*Waterloo			204,720
*Preston			114,193
*Hespeler			51,520
*Galt			264,543
Totals	$7,669,102	$10,334,100	$12,880,893

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*Subject to Addition of Municipal Distribution Cost.

Service Rates:

I.—Motor Service Per H. P. Per Annum: 24-Hour Service at Consumers' Premises:

Municipality.	30,000-H. P.	60,000-H. P.	100,000-H. P
Toronto	24.61	17.04	15.40
London	55.60	25.13	21.09
Brantford	32.54	19.19	16.33
Guelph	30.36	19.58	17.50
Stratford	36.30	22.75	20.20
Woodstock	37.06	22.34	18.31
Ingersoll	36.56	22.90	18.77

II.—Arc Lighting: Cost Per Lamp Per Year.

Municipality.	30,000-H. P.	60,000-H. P.	100,000-H. P.
Toronto	44.66	38.92	37.28
London	56.61	46.15	42.11
Brantford	52.25	44.17	41.31
Guelph	50.52	42.01	39.93
Stratford	59.46	48.53	45.98
Woodstock	58.74	49.45	45.42
Ingersoll	75.18	65.31	61.18

III.—Incandescent Lighting: Cost Per K. W. H.

Municipality.	30,000-H. P.	60,000-H. P.	100,000-H. P.
Toronto	.0801	.0670	.0633
London	.1213	.0956	.0857
Brantford	.1007	.0809	.0739
Guelph	.1205	.0997	.0946
Stratford	.1282	.1015	.0953
Woodstock	.1377	.1126	.1017
Ingersoll	.1385	.1143	.1042

IV.—The surplus power generated and transmitted with the object of serving the subsidiary municipalities would cost at the municipal sub-station switch-board as follows:—

Municipality.	Cost Per H.P. Per Annum at Municipal Switchboard.
Hamilton	$ 9.61
St. Thomas	15.89
Paris	12.95
Dundas	11.86
Mitchell	25.41
St. Mary's	20.47
Berlin	13.42
Waterloo	15.31
Preston	16.77
Hespeler	20.88
Galt	16.62

Additional capital outlay that would be incurred by the development of site No. 2 and site No. 1 respectively, over and above that attached to the development of site No. 4.

Additional cost of:	30,000-H. P.	60,000-H. P.	100,000-H. P.
Site No. 2	$1,278,678	$1,273,735	$1,265,996
Site No. 1	1,475,717	1,470,775	1,463,036

APPENDIX "B."

Miscellaneous Matters.

I. The length of time required for the completion of the proposed works has been estimated by the engineers at from two to three years. They believe that under strong and vigorous construction management they might be completed within two years.

II. Interest and sinking fund have been computed on the capital costs as follows:—

1st.—On the Niagara Falls Development, assuming a construction period of three years.

2nd.—On the transmission line, the municipal sub-stations and the municipal distributing stations and equipment, assuming a construction period of two years.

The total amount of interest and sinking fund, which it is estimated will accrue to the construction period, and in consequence, require to be paid out of capital is: for the 30,000-H.P. development, $389,563; for the 60,000-H. P. development, $536,614; and for the 100,000-H.P. development, $698,044.

III. Under thoroughly competent executive management there does not seem to be any good reason why the undertaking should not be made self-sustaining within two years from the date of the completion of the works. Contracts with consumers will be made gradually, but the advantage in rates over existing commercial rates is so great that there should be little difficulty in securing them. If, however, contracts should be made in the meantime between competing electric power companies and consumers who otherwise would become customers of the Municipal Electric Power Corporation, and, in consequence thereof, the Municipal Power Corporation were unable to effect the sale, within the said period of two years, of the whole of the output necessary to pay expenses, the initial rates of the latter Corporation might be loaded to cover the estimated deficiency for the period thereof.

IV. The water rentals payable to the Queen Victoria Niagara Falls Park Commissioners have been estimated at the same rates that the several chartered companies now in existence pay. The Park Commissioners have agreed with the companies in question that no right to use the waters of the Niagara River within the Park shall be given on more favorable terms than the existing companies enjoy.

V. The computation of interest at the rate of 4½ per cent. does not mean that, in the judgment of the Commissioners, the municipalities concerned will require to pay that rate of interest upon the necessary loan. The municipalities will at the proper time borrow at the best rates that the market permits of, but it was deemed wise to load the operating costs with an outside interest rate of 4½%. The undertaking could —on the operating costs worked out—very well carry this rate of interest. The difference between the said rate of 4½ per cent., and the rate at which the municipalities actually borrow may be rebated in favor of the Operating Commissioners, or may be retained as a profit by the municipalities interested, as may be arranged when the proper time comes.

VI. The municipalities of Woodstock and Guelph own, it is understood, their own electric lighting plants. No allowance has been made in the costs submitted hereunder for the utilization of any part of these plants. An entirely new undertaking from beginning to end has been estimated upon. In the event therefore of these plants being utilized or liquidated, the capital costs estimated herein will be reduced accordingly.

SPECIAL ARTICLES BY PROFESSOR FESSENDEN.

Cheap Power.

Cheap power is the most important factor in the industrial development of a country or province, and cheap power means water-power, for power can be produced hydraulically under favorable circumstances at a small fraction of the cost of producing it by steam. This condition is likely to obtain until some means is invented of deriving energy direct from the sun's heat, and at present there is no immediate prospect of this. Moreover, the difference in cost between hydraulic power and steam power will probably be considerably accentuated within the next fifty years, on account of an increase in the price of coal, since there is little prospect at the present time of any considerable increase in the thermo-dynamic efficiency of heat engines.

Although the use of water-power antedated the steam engine, this use was limited even after the manufacture of steel was sufficiently advanced to furnish the necessary machinery, because the power could not be distributed. Therefore for many decades cheap power meant cheap coal and it is only recently, since the perfection of means for distributing power electrically, that water-power has come to the front.

Short as the time has been it has proved that such countries as Norway, Sweden and Switzerland, heretofore reckoned among the poorer countries, have in their waterfalls a source of wealth more valuable than gold mines, and every indication at the present time is to the effect that these countries will in the near future develop to an extent which twenty years ago would have been considered incredible.

With the exception of the Dihang in Northeastern India and Thibet there is no water-power in the world comparable with that obtainable in the neighborhood of Niagara Falls. This section of the country has in this water-power an asset destined to make it perhaps the foremost manufacturing centre in the world provided its development is not checked by legislation. Considered as a natural asset the gold fields of the Rand are relatively of small value compared to the value of the water-power of Niagara Falls.

Niagara Falls:

A source of water-power is valuable to a country both directly and indirectly. Directly, in the actual cheapening of the cost of power; for example, if a manufacturer pays a thousand dollars yearly for coal, labor, rent and insurance to produce by steam the power he needs, and he can develop a water-power which will give him the same amount for $250 a year, the hydraulic plant is worth to him $750 a year. Indirectly, if the manufacturer finds that his operations are conducted more efficiently, that his yearly output is larger, that he can deliver his goods to market cheaper, that the ability to obtain cheap power has led other manufacturers from whom he purchases supplies to locate near him, and if as a member of a large manufacturing community, he can obtain freight rates and access to markets which as a member of a small manufacturing community he could not get.

Considering the first of these alone, the direct value of the water-power obtainable from the flow from Lake Erie into Lake Ontario is conservatively estimated at $2,000,000,000.

It may be advisable to show how this figure is derived.

Estimates of the flow of the Niagara River vary somewhat, but we may take as the average flow 75,000,000 gallons per minute. Taking the difference of level between the two lakes as 320 feet, this gives a figure of approximately 6,000,000 horse-power.

Under an adequate development and other conditions such as obtain in a hydraulic plant of this character, a horse-power year can be developed at a cost which is at least from $15 to $70 less than that for which it can be produced by steam. Assuming an average difference of only $20, the annual saving in cost when the full amount of power is developed will be $120,000,000. This represents the interest at five per cent. on more than $2,000,000,000, and the capitalized value of this saving to the people of the Province of Ontario may, therefore, be taken as more than $1,000,000,000.

The above estimate is a conservative one. In practice the average cost of a horse-power year produced by steam is found to be considerably greater than that assumed, and a value of more than $250,000,000 per annum would be found to be more nearly in accordance with the actual facts.

To produce this horse-power by steam would require more than 60,000,000 tons of coal each year. This figure is a conservative one, as an actual average of the amount now used per horse-power would give a higher figure. As the average tonnage mined per year per man employed in the coal mines is 600 tons, it will be seen that the present waste represents the labor of 100,000 additional men in the coal mines. Incidentally it represents also an annual loss of 300 lives, and more than 1,000 serious casualties from accidents in the mines.

In the above estimate of the value of this water-power to the Province no account has been taken of the fact that where coal is mined abroad and brought into the country so that the money received by the miners is spent outside the country using the coal, the loss from failure to employ available water-power is much greater. Nor has any account been taken of the great indirect economic gains accompanying the adoption of electricity for power purposes.

An available head of 320 feet has been taken instead of the head of 160 feet which is actually obtainable at Niagara Falls. A head of 320 feet was taken because there would appear to be no engineering reason why this head could not be obtained by going across the Niagara Peninsula instead of to the Falls. In addition to the much higher head obtainable by going across the Niagara Peninsula and the consequent cheapening in the hydraulic and electric installation, there is the further advantage that to obtain the same amount of power at the Niagara Peninsula only one-half as much water would be needed as at the Falls, and consequently twice as much power could be obtained for the same diminution in the flow of the Falls.

The matter may be presented in still another light. It is hard to grasp the meaning of such figures as $2,000,000,000, or $120,000,000 per annum, or 60,000 tons of coal per annum, or 6,000,000-horse-power.

When, however, we realize that 6,000,000-horse-power is more than the power of all the steam engines and boilers in the United Kingdom of Great Britain and Ireland, we begin to get an idea of what these figures mean.

Since the balance of this report was written Mr. G. T. Beilby has published his presidential address on the subject of the Coal Consumption of the United Kingdom. He shows that the entire output of all the steam engines and boilers in Great Britain is approximately 5,000,000 horse-power, and that the total annual coal consumption for railways and factories is 66,000,000 tons.

In other words the water-power derived from the Niagara River is capable, could it be transmitted, of operating every manufacturing establishment and railroad in the United Kingdom of Great Britain and Ireland and at a small faction of the cost.

And this again is not a complete statement of the facts, for it has been found from an extended practical experience that where electrical driving is used, on the average less than one-half the power is required, for reasons given in another portion of this report.

The Aesthetic Value of Niagara Falls:

There is at the present time a movement having as its object the enactment of legislation which shall prevent the futher utilization of Niagara Falls for power purposes. The movement would also logically include in its scope the diversion of water through the Chicago Drainage Canal since this also diminishes the flow of water over the Falls.

The sentiment which gives rise to such movements is so long as it is tempered by reason, admirable. There are probably few who would not consider a natural landscape more beautiful than a field of wheat, or forests than city buildings, but it is generally recognized that to restore everything to its natural conditions, if the power to do so were given, would mean the end of human progress. This question differs from the usual national park movement in that it is not a question of preserving natural scenery at the cost of a few pelts, or of a few acres withheld from cultivation, but of abandoning what is undoubtedly one of the greatest natural assets which Providence has placed at the disposal of the people, and of placing in consequence a crushing burden upon the country's development.

The price to be paid by the people for preserving Niagara Falls in its original state should be estimated in the same way as the price of any other artistic luxury. The price is, as has been shown above, not less than $120,000,000, and is more probably above $250,000,000 per annum, an amount larger than the total income of many countries, and equivalent to an annual tax of $50 per head on a population of 5,000,000. It is a matter for serious consideration whether at the same cost results of more benefit could not be obtained in other directions.

The Incidental Advantages of the Use of Electrical Power:

The employment of electricity carries with it other advantages in addition to that of cheaper power, and these are, in some cases, of greater importance.

The use of electric power for street railroads and the consequent cheapness and increased rapidity of transport has, by widening out the living radius, contributed greatly to the comfort of the laboring population, and diminished to a considerable extent, unhealthy crowding in city tenements.

In the factories themselves the use of electric motors for driving electric machinery, by doing away to a large extent with pulleys and countershafts, has made machine rooms healthier, cleaner, and better lighted.

As the result of an investigation covering more than one hundred plants, varying in size from the Baldwin Locomotive Works, down to plants employing not more than one hundred horse-power, it was found that the introduction of electric power reduced the average power needed in factories running at varying loads to one-third of what was required when steam was used. This reduction, much greater than was anticipated, was found to be due in part to the fact that in the great majority of such factories, the power used in turning the shafting and countershafting absorbed the largest part of the energy.

Another unanticipated advantage, but one which experience has shown is a very important one, is the fact that a much greater output is obtained under the improved conditions from the same machinery, owing to the increased facility for operating at maximum output. Another is that more machinery can be employed in the same floor space. Other incidental advantages are greater flexibility of operation, the fact that one section of a factory can work overtime without the necessity of running the entire power drive, the ease in changing the position of machinery, the saving of the floor space which would otherwise be used by engine and boiler, the saving in the cost of the heavy structural work necessary to support long lines of shafting, and the increased facilities for using cranes in consequence of the absence of much overhead shafting.

The benefits, however, are not limited to the manufacturing population. Whether small motors may or may not be usefully employed for many purposes about a farm will doubtless depend upon the conditions, and in many cases this use of electricity will be of but little importance to the farmer.

The ability, however, to get farm products into market quickly and cheaply is a matter of capital importance. With the system of light electric railroads now in use in many districts, it has been found that the long drive, in many cases over bad roads, and the consequent slow delivery and waste of time on the part of the farmer and his horses, can be avoided, and that produce can be delivered not only quicker and in better condition, but at less cost, and that the time of the farmer himself and his horses is made available for other work. With this comes an increased facility in obtaining goods from town, an increase in the volume of trade, better mail facilities, a doing away with the considerable degree of isolation which necessarily obtains where there is no convenient and quick means of transport, and a bringing together of the farming body into one solid community, and a raising of the whole standard of living.

Engineering Undertakings Considered in Relation to State and Municipal Control:

It is becoming more and more generally recognized that undertakings founded on the great public needs of the highly organized society of modern times should be controlled by society. The abuses of independent control, imposing loss and injury upon the public, have been demonstrated so frequently that a large and weighty volume of public opinion has been formed which holds that it is absolutely necessary in the public welfare that municipalities should have power to control, operate, and initiate public utility undertakings.

Whether, having the power, it is advisable, that municipalities should actually engage in such undertakings, or whether they should merely maintain their control, as it has been aptly put, through their powers as a landlord, is a matter which will be determined by the municipalities from political, social, and economic, as well as engineering, considerations.

Considering the question from its engineering side alone it is found that from the very essential nature of the matter only a certain class of engineering undertakings can be efficiently and properly operated by states or municipalities. It is very important that this limitation should be recognized, as where the limitation has been overstepped, it has resulted in heavy financial losses to the governing bodies immediately concerned, it has seriously checked development in engineering lines, and these results have in consequence afforded a strong argument to those opposed to municipal operation of public utilities.

The distribution of power from Niagara Falls is proposed for the reason that it is an improvement on the present methods of obtaining power. Improvements in engineering methods are, however, only made through the expenditure of large sums of money for experimental work. The original development of electrical power on a large scale at Niagara Falls was rendered possible by the development of the two-phase induction motor. The exact figures in this case are not known, but it is believed that considerably over $1,000,000 was spent in perfecting this invention before any return was received. To take a case from another industry; it is understood that one of the German chemical firms spent $4,500,000 in the development of artificial indigo, and instances within the writer's personal knowledge include the expenditure of $2,500,000 in developing a new method of making window glass, and the expenditure of more than $500,000 in developing an electrical invention. It can hardly be questioned that the executive head of a municipality or state would not feel justified in spending several million dollars of public money in attempting to develop an engineering improvement, in view of the fact that only a small fraction of such attempts are successful.

Further, communities and their executive officers would generally lack the incentive of personal and corporate gain, especially if all similar undertakings were under state or municipal control, and would, therefore, to such extent be deterred from advance.

It is true that under state or municipal operation some minor and sporadic developments may be expected, but nothing of a general or important character. Important developments generally come only from the hands of individuals or bodies responsible only to themselves, and provided with the incentive of a large profit. The elimination of self-responsibility and incentive would inevitably produce a condition in industrial and scientific development analogous to the Dark Ages.

It is to be noted that this conclusion is derived from engineering considerations alone, and does not include any consideration from the political, social, or economic sides. There may, it is conceivable, be political, social and economic considerations alone, there can be no question but that the field of state and municipal operation which tend to affect this limitation. Considered however from the engineering standpoint should be limited to undertakings in which there is no immediate prospect of, or need for improved method.

Is the Generation at, and Transmission of Power from, Niagara Falls by the Municipalities Advisable from an Engineering Standpoint?

Considered from an engineering standpoint solely, there is no reason why the municipalities concerned should not undertake the work of transmitting power from Niagara Falls. This is a case where no very marked improvement in the generation of power is possible.

It has frequently happened that broad statements to the effect that certain things were not possible have been later contraverted by the facts. In the case of the first large development of power at Niagara Falls some of the most eminent experts consulted, reported that it was impossible to use an alternating current for this purpose successfully, but it is now realized that no other method would have given satisfactory results. As to the possibility of accomplishing results by a given method, prediction is always unsafe. As to the possibility of obtaining more energy from a system than is put into it there is no uncertainty.

At the present time, the efficiency of water turbines such as it is proposed to use at Niagara Falls is quite high. Future developments in turbine design may add a few per cent. to the efficiency, but there cannot possibly be any large gain, for the reason that the turbine now converts by far the greater part of the energy which is put into it. The same remark applies to the electrical generating plant since electric generators may have an efficiency as high as ninety-seven or ninety-eight per cent. The structural work connected with the undertaking is of a kind little liable to depreciation, and may be kept up at small expense. There is comparatively little loss in the transmission lines proposed.

Whatever improvements, therefore, may be made in generating electricity from water-power, we may be sure will not be large, and this undertaking, therefore, comes within the class to which there is no engineering objection as a municipal undertaking.

Loss of Capital Through New Developments:

A danger which is always associated with the ownership of industrial undertakings is that the capital invested may be lost through the development of new and cheaper methods and processes. The extent to which industrial machinery of certain types is rendered obsolete by new improvements is not always realized. The writer is personally acquainted with one street car railroad plant in which the entire electrical equipment of the power-house was thrown out and replaced with improved machinery four times within a period of ten years. The Carnegie Company is reported, correctly it is believed, to have scrapped on one occasion more than $1,000,000 worth of new machinery which had never been used.

This has already become a serious matter for many municipalities who have engaged in undertakings lying outside of the engineering limits defined above. Many of these municipalities installed plants for the production of electric light at a time prior to the advent of important improvements in generating and distributing electricity and as these municipalities, in common with most municipalities, made no proper allowance for depreciation, the capital invested has been practically lost, and in addition the cost of electric light to the consumer is much higher than it is in other places equipped with later and more economical types of machinery. In addition, heavy and expensive repairs have been necessary, and the taxes correspondingly increased. This has reacted upon the municipalities since the heavy rates have caused manufacturers to move away to other towns, and this, again, has still further increased the burden upon those remaining. There are already indications that a considerable number of these municipalities which have engaged in improper undertakings are entering upon a period of financial difficulty.

In the case of the proposed distribution of power from Niagara Falls this danger will not occur from the reason that, as I have pointed out above, it is not possible for any great improvement to be made in methods of generating electricity from water-power as the present methods utilize nearly all the available energy. The proposed power plant can, therefore, be safely undertaken with the assurance that there is no possibility of the plant becoming obsolete through inventions having an appreciably greater converting efficiency.

This does not mean that slight improvements will not be made, especially in the transmission system, but the cost of such changes, if it should be decided that they are advisable, should not prove a serious burden on the annual revenue.

Is the Operation by the Municipalities of Lighting Plants Advisable from an Engineering Standpoint?

Electric lighting does not, from an engineering standpoint, fall within the class of undertakings which can be efficiently and properly operated by municipalities; the reasons for this have been already given. It may, of course, be advisable for other than engineering reasons; and as a part of the proposed large development and transmission scheme, it may be justifiable.

On account of the numerous improvements which are being made in systems of electric lighting, both arc and incandescent, an electric lighting plant may become obsolete in a few years. Not only may more efficient methods of producing light be introduced, but in addition the standard of lighting may change. Within the past twenty years the following systems of street illumination have been used. These are given in chronological order as nearly as possible.

Illumination by gas lamps.
Siemens regenerative gas burners.
Series incandescent lamps.
Direct current arcs.
Arc lamps on high towers.
Wide carbon alternating current arcs.
Welsbach gas burners.
Enclosed arcs.
Nernst lamps.
Magnetite arcs.
Mercury vapor lamps.
Direct current arcs, worked from rectified alternating current.
Impregnated carbon arc lamps.

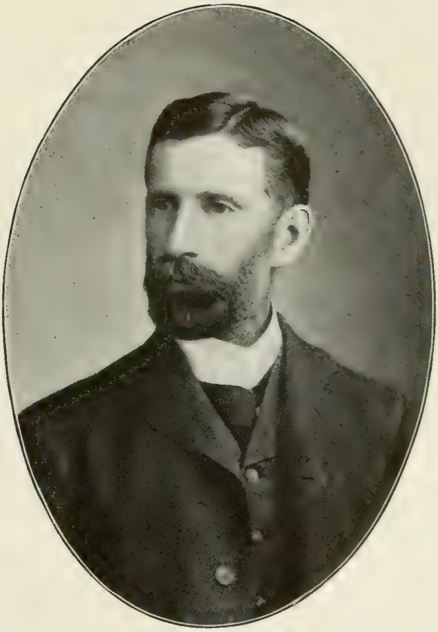
A number of methods of lighting have been omitted, for example, the use of Jablokoff arc lamps; as these were not used to any extent in America.

The last five systems mentioned above are of recent introduction, but some of them will undoubtedly come into general use.

It is probable that no city has used all the above systems of lighting, but there are few cities which have not used at least three or four or more of them.

As an illustration of the rapidity with which improvements are made, at the time the estimates for this report were being prepared, it was decided to figure on alternating current arcs operated from frequency changers, this appearing to be the most suitable and economical method. But though the estimates were prepared on this basis, the development of the mercury rectifier for operating arc lamps from alternating currents has already reached such a point as to make it practically certain that it will come into extensive use, and it is quite possible that had this report been prepared a year later this system would have been estimated on instead of the one actually taken.

The same remarks apply to incandescent lighting. Within the last few years no less than three or four different types of incandescent lamps have been introduced, including the Welsbach lamp, the tantalum lamp, the osmium lamp, and the graphitized



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filament lamp. Some of these lamps can be used on existing circuits, and necessitate no change in voltage or the amount of copper in the distributing circuits. Other types of lamps, however, call for considerable and expensive changes.

The Engineering Features of the Proposed Undertaking.

The engineering work proposed is of a comparatively simple character. The hydraulic and electrical apparatus has been standardized. The character of the rock to be excavated for the tunnels and wheel-pits is known and advantage can be taken of the experience obtained in constructing similar works in the neighborhood.

The transmission lines are also of a type which is now standard, and there is nothing experimental about any part of the engineering work.

The site is a very favorable one, necessitating but a short length of tunnel, and there is ample water for the full amount of the power of the maximum installation proposed. The difficulty in obtaining water which has been met with by some of the neighborhood power companies can be overcome by choosing more suitable levels.

Objection has been raised to the construction of a power-house so near the Falls on the ground that it will interfere with the scenic effect. It is proposed to meet this objection by excavating for the power-house and constructing it so that it will be below the level of its surroundings, and invisible.

Estimates of the Proposed Undertaking, Power Plant, Transmission Lines, and Distribution:

The estimates for the proposed power plant have been prepared by Messrs. Ross and Holgate. These have been carefully gone over in detail with the result that it has been found unnecessary to modify them in any way. This detailed examination necessitated a visit of inspection to the proposed site as there was some doubt as to the correctness of the estimate for some of the hydraulic work, but the original estimates of Messrs. Ross and Holgate were confirmed in every particular.

While this is perhaps only what might have been expected in view of the great experience which Messrs. Ross and Holgate have had with this class of work, it is very satisfactory, and the Commission is to be congratulated on having obtained the services of these gentlemen.

The estimate for the cost of power development has been checked by the known and ascertained facts of similar developments.

As regards the estimate for the transmission lines and distribution systems, these have been checked by comparison with the figures for similar transmission lines and distribution systems now in use in a number of places.

As regards the estimates for the capital cost per horse-power generated, it is possible that they may be criticized as being too low by engineers not familiar with recent developments in hydraulic work. In at least one American installation actually completed it has been found possible to deliver power to the switchboard with a capital cost of only $35 per horse-power, and a figure of $27 per horse-power has been obtained at a Norwegian installation of only six thousand horse-power, though in the latter case, the conditions are hardly comparable on account of the lower cost of engineering work.

Estimate of Cost of Power:

The estimate of the cost of power has been made on a conservative basis.

The figures per horse-power year are higher than the price at which power is sold at some Norwegian power plants. This is to be accounted for by the lower cost of engineering work in Norway, and by exceptionally favorable circumstances.

On the other hand it is lower than the cost of production of many power plants in the United States, and it is probably lower than the cost at which it can be produced at most of the present power plants at Niagara Falls. This is to be accounted for by the fact that the earliest installations at Niagara Falls had additional expenses, as is the case with all pioneer work, above those necessary in the case of the proposed installation.

In this connection it should be carefully noted that no allowance for taxation was made in preparing these estimates, the undertaking being by Statute specially exempted from taxation. Ample allowances for depreciation of the power plant and transmission lines for repairs, etc., were included in the estimates as will be seen from the tables attached to the report.

Electric Lighting Estimates:

The figures for the cost of electric lighting are believed to be conservative.

They include for the reason already stated, no allowance for taxation, but what is believed to be ample allowance for depreciation, repairs, etc., as will be seen from the annexed tables.

These figures may be criticized on the one hand as being too low. A careful consideration, however, will show that there are a number of conditions favorable to a low cost, for example, cheap power, and the absence of a large central station.

On the other hand, the estimates may be criticized as being too high by those familiar with the figures given by some municipal plants, but who are not familiar with the system of book-keeping employed at these plants. Where no charge is made for water, or, as in some cases, even for labor, or for power, and no allowance for depreciation or renewals, a very low figure may apparently be obtained. Absolute reliance cannot be placed upon the figures which have been published as to the cost of electric lighting in municipal plants.

Load Curves:

It is not possible to determine from engineering considerations the price which should be paid by consumers for power in any case met with in practice. More especially is this impossible in a case such as the one under consideration, where the capital costs amount to almost the entire cost of power.

This is for the following reason:

If there were but a single consumer and he used the block of power represented by the square A in Figure I, the question would be a simple one. If he used a thousand horse-power, the company would have to supply the apparatus necessary to furnish that thousand horse-power, and the capital cost of this apparatus and of the labor, etc., would be easily calculated.

In an installation of the proposed type it would make very little difference whether he used that power for one hour or twenty-four hours, since the plant must be there to furnish power, and the capital charges go on just the same whether the power is being used or not.

Supposing another consumer were to take power represented by the block B. Between the hours of seven and nine the company would be furnishing two thousand horse-power, and consequently the cost to the company practically double what it was before. If, however, the second customer instead of using his power as shown by the block B, used it between the hours of noon and two p.m., as shown by the block C, the company would be at no additional expense, for the same apparatus which supplied the first customer between the hours of six and ten p.m., could supply the second customer between the hours of noon and two p.m., and the additional labor cost would be very small.

Consequently, if the company had a consumer taking power represented by the block A, it could afford to supply power to a customer taking the block C at a comparatively low rate, since the company would be at no appreciable additional expense.

In practice, however, what the company would do would not be to leave the charge for the block A the same as before, and make a trifling charge for the block C, but to reduce the charge for the block A and make a charge per horse-power hour for the block C nearly approximating that charged for the block A.

It will be seen therefore that the price to be charged for power depends upon how many consumers there are, and the time of the day at which they require the power.

It is obviously to the interests of the company or corporation supplying the power to have the upper outline of the blocks of power form as nearly a straight line as possible, for when this is the case, the plant is working all the time at its full capacity, and delivering the maximum amount of horse-power.

This process of making the load curve as near a straight line as possible is called flattening the load curve.

The load curves for different classes of power vary greatly not only with the character of the community, but also with the season of the year and the character of the service. In Figure 2 are given some illustrative curves, not representing any particular case, but showing merely the general character of such curves. The full line curve represents a lighting curve. Here little power is used for lighting during the day time, and a large amount of power between the hours of 6 and 11 p.m., the maximum amount being used about 9 p.m.

The dotted line represents in its general character a street railway power curve.

It will be observed that while the maxima of these curves do not coincide, they are both large in the evening after 5 o'clock, and lower after 12 o'clock at night, and during the greater part of the day. Consequently, if the power corporation could sell power to some company which would agree to use the power during the hours when the load was relatively lighter, as shown in the dot and dash load curve, the power corporation could afford to offer extra inducements.

In England, and in other countries, a great variety of plans have been tried at one time and another; for example, what is known as the maximum demand method, and the method of making a lower price for power used between certain hours of the day. This subject is a very complicated one.

Broadly speaking, however, the general object of the manager of the power company is to flatten his load curve as much as possible by finding new uses for power during the hours of light load.

Electricity as a Heating Agent:

The question of heating by electricity has always attracted considerable attention in this connection, and as regards the heating of houses and light cooking, there is undoubtedly a considerable field for electricity. Unfortunately, however, electricity is unsuited for heating water, as water has a very high specific heat. It is possible that in the near future a combination system may come into use in which coal is used for heating water and for heating apartments which must be kept warm during the entire twenty-four hours, and electricity is used for such cooking as does not necessitate heating water, and for heating rooms which are only used during a small part of the day.

REGINALD A. FESSENDEN.

Fig. 1

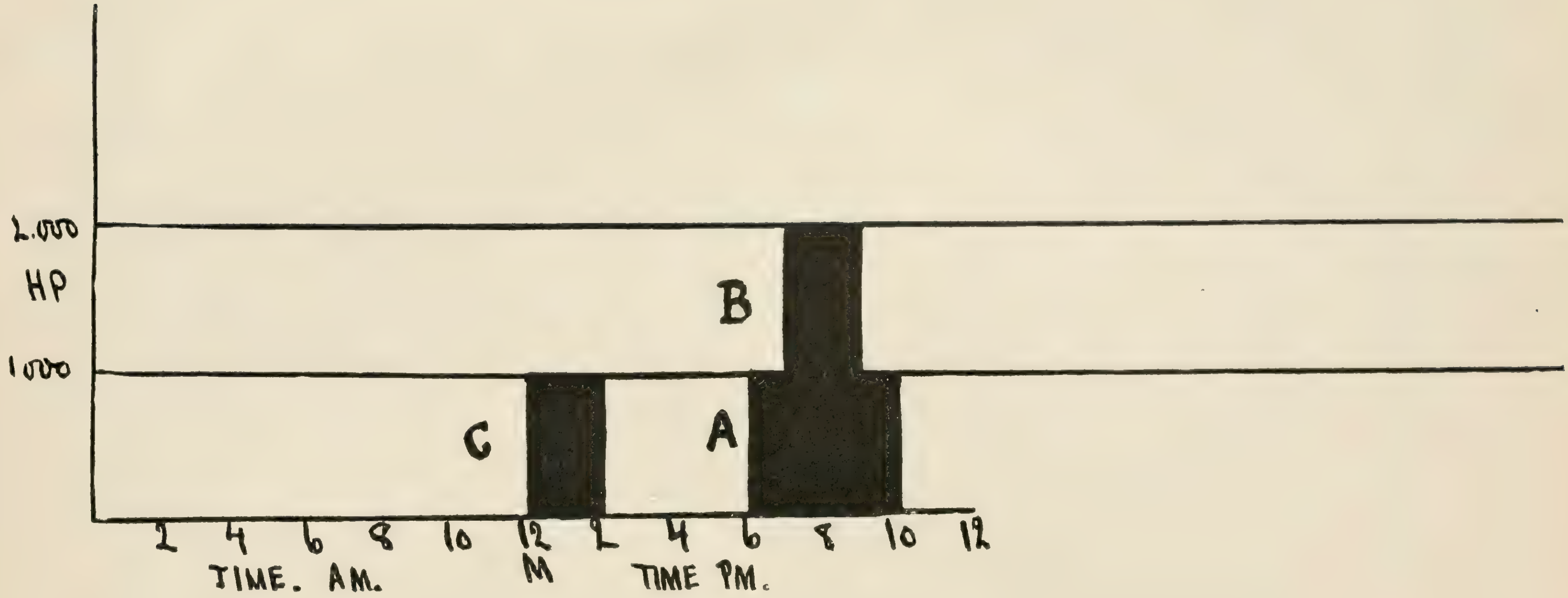
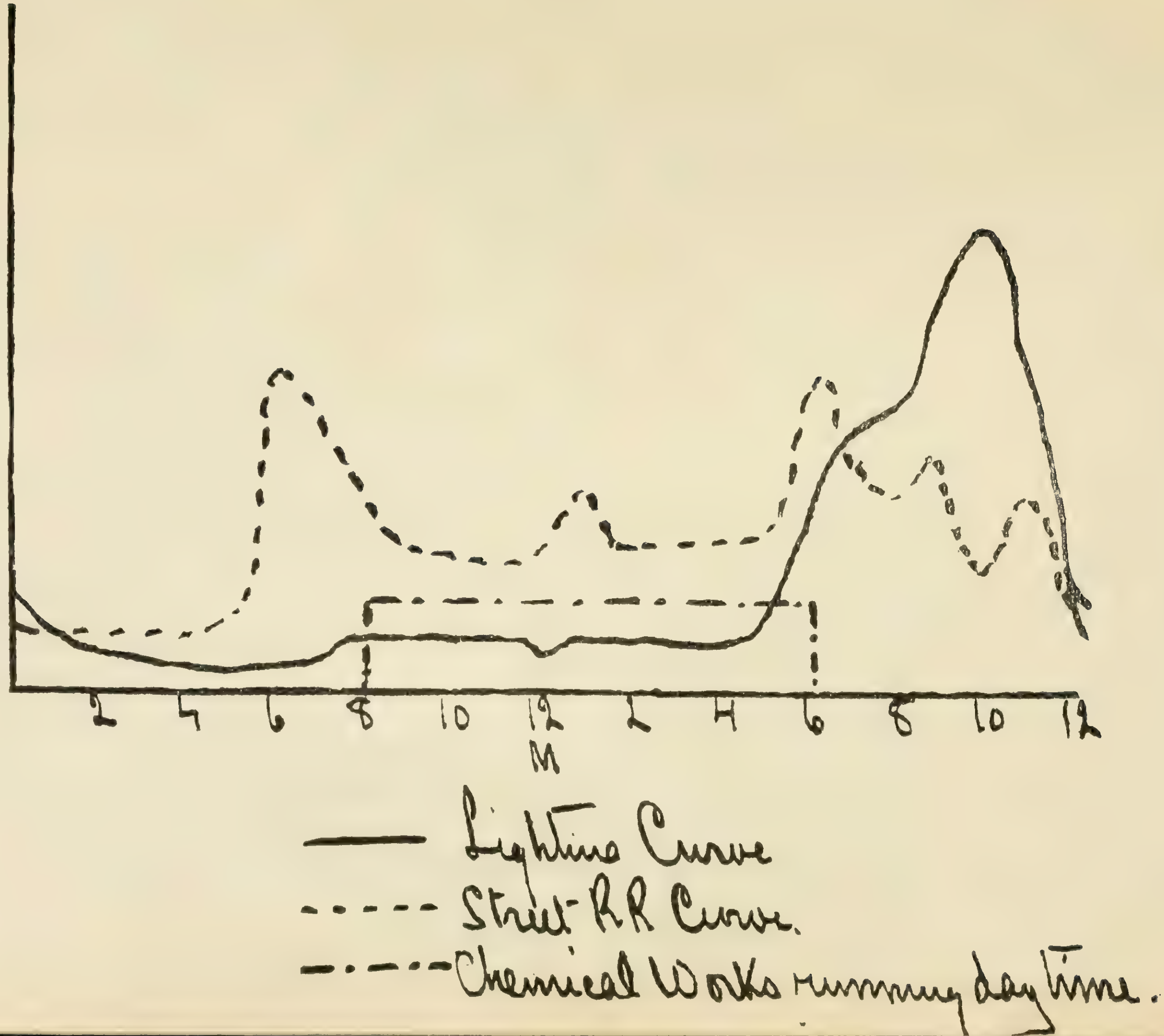


Fig. 2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Lighting Curve
Street RR Curve.
Chemical Works running day time.

REPORT OF ROSS AND HOLGATE,

Consulting Engineers to the Ontario Power Commission, as to Power Users' Requirements and Cost of Power.

SCOPE OF ENQUIRY.

We were instructed that this report should include an investigation of the power requirements for all Municipal, Manufacturing, and general motive power and lighting purposes within the limits of the seven municipalities of Toronto, London, Brantford, Guelph, Stratford, Woodstock, and Ingersoll, and should set forth the capital and yearly costs per horse-power for a power development suitable for their requirements, and the transmission and distribution costs of same, together with information relating to the present cost of steam power in the Districts.

We have not, however, confined the report within these limits, but have extended it beyond the seven to include eleven additional municipalities, with a population of 2,000 or over, which are within easy transmission distance of the original seven. These are as follows:—Hamilton, St. Thomas, Paris, Dundas, Mitchell, St. Mary's, Berlin, Waterloo, Preston, Hespeler, and Galt.

In addition to the extension of the number of municipalities beyond those which we were instructed to investigate, we have estimated the capital costs of generating plants at four separate sites at Niagara; and we have estimated the cost of the development and transmission of power from two of these, not only on the basis of the present requirements of these eighteen municipalities, but also allowing for their future expansion. We have thus worked out the capital and operating costs in full for a 30,000 H.P., a 60,000 H.P., and a 100,000 H.P. development.

This extension of the investigation beyond that which we were instructed to make has more than doubled the estimating involved, but we believe that the value of this report is greatly increased thereby.

The scheme of arrangement adopted throughout this report is as follows:—

(1) A consideration of the power demands of the municipalities.
(2) An investigation of the power sites available.
(3) Capital costs of developing, transmitting, and distributing power.
(4) Operating costs per year for developing, transmitting, and distributing power.
(5) Yearly costs of transmitted power at customers' premises.
(6) Yearly costs of steam power for various sizes of plants.
(7) Yearly costs of gas power for various sizes of plants.
(8) General conclusions.

Investigation of Requirements:

The investigation of the requirements for power, not only for municipal, but for manufacturing purposes, within the bounds of the seven municipalities interested, was carried out through a canvass by a staff of engineers, with headquarters in Toronto, every power user being visited and his power requirements ascertained to the fullest degree possible, the information being entered upon data sheets, which were then transferred to the head office in Montreal, where the whole was worked up into the final tables herewith presented and divided among classes of users as shown.

It was found that the vast majority of power users assisted the canvassers, and gave free access to information relating to their requirements. In a few cases, however, such facilities were not accorded, but allowances were made to cover these, so that it is confidently believed that the canvass made covers thoroughly the requirements for power for all purposes within the seven municipalities interested, and in the case of Toronto within its suburban districts also.

These enquiries were adapted to the separate conditions of both steam plants and electrical plants, as the data required in each case varied. In addition to the actual horse-power capacity and consumption, notes were taken on related matters, such as costs of coal, probable increase of power in the immediate future, methods of heating and lighting the premises, uses of exhaust or live steam for heating or for industrial purposes, the amount of shavings or other refuse which were available for fuel, all of which vitally affects the market for power. No separate canvass was made of the requirements of the eleven additional municipalities, but they were carefully estimated from appropriate comparisons made with the known conditions in the original seven, and from lighting data procured from Government reports. It is believed that a fair estimate has thus been made of the requirements of the eleven additional municipalities.

Present Horse-Power Ratings of Plants Installed:

In Table 1 is shown the horse-power ratings of plants installed at present in the seven municipalities, for manufacturing, power and lighting, divided into boilers, engines, generators, motors and gas engines. A column is also inserted showing average loads. These loads were obtained under actual investigation of the plants visited from statements of proprietors or engineers, and from indicator cards, electric meter readings and meter accounts.

A column headed "Future Requirements" indicates what, in the opinion of the interested parties, their requirements will be within two years. This last column, therefore, shows what the power requirements within the bounds of the seven municipalities should be by the time a Generating and Transmission Plant could be constructed to meet their demands.

It will be seen from the tables that if all the requirements within the seven municipalities were met by the use of transmitted power, 87,883 horse-power would require to be delivered. This, however, is in excess of the transmitted horse-power which might be anticipated to be sold owing to certain conditions of manufacturing, which would render it uncommercial for certain plants to use transmitted power.

It may be noted that while 78,592 rated horse-power of engines is installed that the present loads are 73,631, indicating that the full capacity of installed engine plant is being utilized. Upon a study of the requirements of purely manufacturing companies, apart from street railway, lighting and water companies, it is found that for these alone the average loads average about 75 per cent. of the rated horse-power of the engines.

It is, therefore, necessary to estimate from the said table what amount of power might be anticipated to be commercially available as a market for transmitted power, and to obtain a basis for estimating these requirements, the present total demands have been divided into several classes.

Available Power Market, Seven Municipalities:

Having shown in Table 1 the rated horse-power of the various engines, boilers, gas engines, etc., and their average loads, the question arises as to what proportion of these plants may be estimated upon with certainty as being customers for the transmitted power, provided that power be delivered at fairly low rates, such as may be anticipated to be probable, if power be obtained from the operating commission. Several considerations will affect the results vitally. So far as plants at present using electric motors are concerned, these form a readily available market. Of those using steam power at present and having no additional or supplementary demands for steam, a large portion should come within the class which cannot afford to ignore the offers of transmitted power. Similarly, central electric stations may also be considered as available customers. On the other hand, where steam is used for industrial purposes other than for power, or where the exhaust steam from the engines is used for heating in winter time, the use of transmitted power becomes less desirable from the point of view of the customer, as in many cases steam will have to be maintained for heating during the winter, and perhaps continuously during the year for dyeing, steaming, and other industrial purposes. Further, in many places by-products, such as shavings and wood scrap, are available for the production of a certain portion of the steam required for power, thus limiting the market. The use also of oil and gas engines is to be considered, and the latter especially, if of a modern type, using producer gas, are more easily and cheaply operated than steam plants of similar size, and consequently there is less probability of their changing their motive power.

In order, therefore, to enable a fair estimate to be made of the market available to the Operating Commission, we have separated in Table 2, the power demands into groups as below:—

A. Those using stationary electric motors at the present time which may be readily obtained as a market.

B. Those using steam-driven plants of various kinds and sizes for industrial purposes, such as in mills, etc., where the engine is belted directly to the shafting.

This covers the larger part of what may be called the industrial plants as distinguished from electric power stations, etc. These plants are operated, generally speaking, ten hours per day.

From Class B has been excluded those using steam for industrial purposes other than the generation of power.

C. Under this classification has been included 24-hour public service plants, such as electric generating plants and pumping stations.

D. Includes such steam plants as, in addition to demands for power, also require steam for other industrial purposes, and also those using, in whole or in part, refuse as fuel.

E. Includes plants using oil and gas engines. There should not be much difficulty in displacing a certain portion of these, especially where producer gas is not used.

In dealing with this question of the available market, practically each plant was considered by itself, so that the results as shown in Table 2 may be taken to indicate conservatively the amount of power which is certainly available as a market, and which can in all probability be captured.

It will be seen in this connection that while the probable demands for power are shown in Table 1 as 87,883 H.P., the actual present market contemplated as certain to be captured is only 55,556 H.P., as indicated in Table 2; or, in other words, a little over 60 per cent. of the total probable requirements is taken as a basis for the following estimates of the market.

In this it will be noted that no allowance has been made for new industries, nor for the natural growth of the present industries except that contemplated in Table 1 under the heading, "Future Requirements," wherein the probable increased future demands of the present plants are allowed for to cover two years to come, or practically only until such time as the transmission plant shall be constructed and in operating condition. In this and all other tables the word horse-power is used in the sense of the average input of power measured at consumers' premises, or the average power developed or transmitted to obtain such power at consumers' premises.

Power Market Available in Eighteen Municipalities:

In Table 3 is shown the power which it is considered the Operating Commission should be able to sell in eighteen municipalities, provided its power rates are such as would render it inadvisable to continue the general use of steam for power purposes. This table excludes the demands of special cases, such as where large amounts of refuse have to be destroyed, or where steam is required largely for other industrial purposes.

Table 3 is derived from Table 2, so far as seven municipalities are concerned, except that in making up the last column for the seven, certain deductions and additions were made to cover a reconsideration of special cases of individual plants.

For this reason it will be found that the last column in Table 3 does not agree with that in Table 2 in certain small particulars. The last part of this Table, dealing with the eleven additional municipalities considered, has been estimated as already described. Considering, therefore, practically all of the municipalities between London, Niagara and Toronto of two thousand population or over, within fair transmitting distance of the main lines, there is a market available which should be capable of being captured by transmitted power at fair rates of 81,125 H.P.

Power Developments Required:

From the above-mentioned Tables for the seven municipalities the power readily available by transmission is 55,325 H.P., while for the eighteen municipalities under the same conditions there is required 81,125 H.P. Premising that only seven municipalities become interested, it could not be anticipated that the whole of the 55,325 H.P. could be captured at once. It, therefore, becomes advisable also to consider the costs of the development and transmission of a certain portion of the latter figure. We have, therefore, in Table 4, assumed that only one-half the requirements shown would be connected within the first few years. This leads to the consideration of the development, transmission and distribution of three amounts of power.

If to the power required by the municipalities be added the losses in transmission and distribution we have the necessary development at the generating plant to lay down the required power under the three conditions.

These three developments we have designated throughout this report as follows:—

Development "A" indicating half requirements of seven municipalities, or nominally about 30,000 horse-power at the Niagara terminals.

Development "B" indicating full requirements of seven municipalities, or nominally about 60,000 horse-power at the Niagara terminals.

Development "C" indicating the full requirements of eighteen municipalities, or nominally a 100,000 horse-power development.

This fairly indicates the growth of demands upon a plant which had been laid out originally to cover the total requirements.

Water Power Sites Available:

The only practicable water powers available for this district are within the Niagara Peninsula, and generally at Niagara Falls itself, although other powers are, or may be made available between Niagara and Hamilton. At Niagara Falls, on the Canadian side, there are already three developments under construction, and these three Companies have obtained rights from the Victoria Niagara Falls Park Commissioners for power varying from 100,000 H.P. to 225,000 H.P. At Decew Falls the Cataract Power Co., which supplies Hamilton and vicinity, have also established a power station for transmission purposes. There are also several developments under contemplation, involving canals across the Peninsula and permitting of generating stations being placed along the Ontario escarpment.

Inasmuch, however, as the costs of development of these latter powers is somewhat obscure without an investigation, which would take more time and money than is available to this Commission, and inasmuch as the Niagara Falls Park Commissioners have within their gift at least four other sites above the Falls, the development, conditions of which are similar to plants already constructed, and of which the costs may be very nearly estimated, it is considered advisable for the purpose of this report that such powers be estimated upon as are available above the Falls, and which are within the gift of the Park Commissioners, and for which it is assumed that the Commission would pay the same rentals as the Companies already existing. There are also the powers available in the Gorge below the Falls within the gift of the Park Commissioners, but these, owing to their difficult hydraulic construction, and violently fluctuating heads, are not to be considered while there are still power sites available above the Falls.

The accompanying map No. 1, shows the four available sites which are considered in this report. Of these, Nos. 1, 2, and 3 involve the construction of very long tail tunnels up the centre of the river, and similar to but longer than that already constructed so successfully by the Electrical Development Co. Site 4 is one which permits of a very short tail tunnel at correspondingly decreased cost, and it is this development only which is finally considered in this report. The four developments would be practically identical in every respect, except as indicated above, due to the increased length of the tail tunnel, so that, having worked out the capital costs of one of these, the others are readily obtainable by the addition of the necessary cost of the tunnel. These additional costs are summarized in Table 8.

Special Note:

Since writing the above and completing our calculations of costs based on a development at site 4, we have been informed that the Park Commissioners are disinclined to recommend, for scenic reasons, that any development be allowed at the said point. In this connection we would point out that the site in question is especially recommended by Mr. Isham Randolph, C.E., in his report to the Park Commissioners of the 4th of April, 1903, and published in the seventeenth annual report of the Commission. This particular recommendation, which points out that the necessary structure "could be an ornamental, even a monumental, structure," may be found on page 98 of said report. With reference to this site the Commissioners say in their official report:—"Mr. Randolph's report . . . demonstrates very clearly . . . that there are several points where power may be developed . . . one of the locations . . . is quite close to the Falls . . . but the power-house is designed to be subterranean, and nothing but a small building to enclose an elevator would appear on the Park surface." (Vide p. 14, 17th Annual Report.)

We have also been recently informed that another company has advanced claims, which, if conceded, would interfere with a development at this point. These claims, however, we understand, are not conceded, but are disputed; and, inasmuch as the development at Site 4 is the one which we recommend for a municipal development in priority to all others, it would seem to be hardly fair to abandon its consideration merely because of a dispute of unknown value with another company. In view, however, of the facts above mentioned, we have also estimated upon the yearly costs per horse-power at Niagara, at the municipal sub-stations, and at the consumers' premises of the power developed from Site No. 3, which is the next cheapest possible development.

Capital Costs:

Throughout this report capital costs have been considered to consist of the following items:—

1st. Costs of labor and material required for construction, with allowances for contingencies.

2nd. Allowances for engineering, legal and business expenses during the period of construction.

3rd. Interest during construction period upon the bonds issued to meet construction cost.

4th. Sinking fund instalments covering construction period.

As of necessity capital costs for the purpose of this report are first required, they will be considered first for the whole construction, from the power development to and including the delivery at customers' premises.

Niagara Plant Development, "A," "B," and "C."

Development No. 4, which places the power station near the brink of the Falls, is made closely along the lines of those of the Canadian Niagara Power Co., and the Electrical Development Co., on the Canadian side, and of the Niagara Falls Power Co., on the American side. These plants have been thoroughly studied out. Two of those on the American side have been in operation for some years, while the Canadian Niagara Co.'s plant has just begun operation.

There is, therefore, a large amount of data available regarding these plants already constructed, which renders the selection of a scheme of development safe, and the cost of same readily determinable, leading, therefore, to reliable results in the capital costs, which are given below.

In the general scheme of development, as outlined in Table No. 5, it will be noted that, as regards the sizes and capacity of units, and the general lay-out, it is very similar to developments already in operation, and no features are introduced which are new or experimental, but are based upon actual present and successful construction, as exemplified in existing plants at Niagara.

Table No. 7 summarizes the costs of development at Site No. 4, under the headings, Developments "A," "B," and "C." In making these estimates it has been considered that the water development and hydraulic construction would be practically completed for development "C," and utilized for developments "A" and "B," which are, therefore, chargeable with practically the whole of the capital costs of the hydraulic development for the larger scheme. The rest of the plant for which capital costs are shown are chargeable with their proportion of the machinery and buildings required for their particular development. In other words, the hydraulic development would be laid down for development "C" in the beginning, and water wheels, generators, transformers, switchboards, and buildings constructed as required. To each item has been added a considerable percentage for contingencies, which are considered as being heavy for hydraulic development, and very much lighter for machinery, for which prices are well standardized. It will be noted that to the total capital outlay, interest for 1½ years at 4½ per cent. has been added to cover the interest accruing to the construction period, which is estimated to occupy from two to three years. The rate of 4½ per cent. is that which we have been instructed by the Commissioners to use. A sinking fund allowance has also been added for construction period at a rate which would retire the bonds in forty years from the beginning of construction operations. These two items, together with engineering, legal and business expenses, when added to the actual investment in labor and material, make up the total capital costs for the three developments.

Capital Costs, Transmission Lines:

The transmission lines have been laid out as shown on accompanying map, No. 2, on which the full lines indicate 60,000 volt transmission tower lines to the seven interested municipalities, the dotted lines representing 10,000 volt transmission to the remainder of the eighteen municipalities, which are not on the direct lines of the original seven; each full line represents a separate line of towers, each supporting two circuits of three cables each, so that between Niagara Falls and Hamilton there will eventually be eight three-phase copper lines, between Hamilton and Toronto, there will be four. This is for the full 100,000 developed at Niagara Falls. For one-half the power, one-half the copper and a corresponding decrease in towers is allowed. In addition to the main transmission lines, which operate at 60,000 volts, and in order to include the additional municipalities, it is necessary to provide subsidiary transmission lines in two places, as indicated on the map, which shows Stratford as a centre of the subsidiary distribution, supplying St. Mary's and Mitchell at 10,000 volts, and Guelph as the second centre, supplying Waterloo, Berlin, Preston, Hespeler, and Galt at the same voltage.

It will be noted that while a number of smaller municipalities are included within the dotted circles surrounding those towns, that only those of a population of 2,000 and upwards are considered.

In addition to these subsidiary transmission lines there is an extension shown from London to St. Thomas of the 60,000 volt lines.

By the selection of these routes and subsidiary transmissions it has been possible to include nearly all the municipalities between St. Thomas and Toronto with a population of 2,000 or over, and as in addition to the eighteen municipalities there are a number of smaller ones within reach, it is felt that the transmission routes taken will meet the requirements of the most important part of the Peninsula with the least possible expenditure.

The capital costs have been figured, (see Tables 9, 10, and 11), as in the case of the Niagara Development for Developments "A," "B," and "C" at Niagara, and these costs there shown are those necessary for the commercial transmission of the power to the different municipalities under the three conditions of development.

For convenience of expanding costs the lines have been divided into "Niagara-Toronto Line," and "Niagara-London Line," as the requirements of Toronto alone demand separate circuits, while on the Niagara-London Line are connected all the other municipalities.

In all cases for the 60,000 volt lines the right-of-way is considered as having been purchased and fenced, while as regards subsidiary 10,000 volt lines, pole placement rights only have been considered. Although in many cases it will not be necessary to purchase outright rights-of-way through certain districts, it is deemed advisable to consider this as being necessary for the purpose of an estimate.

The line construction for the 60,000 volt lines will be similar to that already in progress between Toronto and Niagara, as it has practically become standardized for high voltage construction for large powers. Towers resembling those in use for windmills are used instead of wooden poles, each one designed to carry two three-phase circuits of 60,000 volts, to be constructed of galvanized steel angles, bolted and braced, of sufficient height to clear such obstacles as may be met.

These towers will be erected on the ground, and the legs sunk therein about six feet, each foot resting on a solid cedar block; concrete foundations will be used wherever required. Special designs will be used at the crossing of the Welland Canal, the height being such as to admit of the passage of vessels.

The copper for these lines has been designed for a 10 per cent. line loss to Toronto, and the same to the centre of distribution on the London line, and all for a power factor of 80 per cent., and a delivery voltage of 54,000. These lines have been arranged to operate in parallel, and enter and leave each sub-station in such a way that sectioning of the line is obtained to permit of any section being cut out for repairs without crippling in any way the rest of the circuit.

The necessary disconnecting and sectionalizing switches have been considered to be a part of the line, and are included in the capital costs of the same, and not in the sub-station costs.

A telephone line is provided, mounted on separate poles, and placed so as to be as free as possible from inductive influences and from possible contact with the high voltage lines. In most places it would be advisable to run this telephone line along adjacent highways rather than on the right-of-way of the main transmission line.

In Tables 9 and 10 are shown capital costs of the transmission lines for developments "A" and "B," while Table 11 shows cost for development "C," and includes the St. Thomas extension, and the Stratford and Guelph sub-systems. To the total costs of construction has been added the usual allowance for engineering, legal and business expenses, and interest and sinking fund for one year, on the assumption that a total of two years would be required to complete the construction.

Capital Costs Municipal Sub-Stations:

Power having been laid down at the end of the transmission line at each municipality at 60,000 volts, it becomes necessary to transform it to a voltage suitable for distribution. In all municipalities except Toronto the voltage is transformed from 60,000 to 2,200 for local uses; in Toronto, however, owing to the great area to be covered, it is deemed advisable to distribute from the 60,000 volt sub-station at 10,500 volts to three subsidiary stations from which distributing lines issue to the streets at 2,200 volts as shown in Map No. 3, attached. At Guelph and Stratford, in addition to the local requirements of 2,200 volts, provision is also made for a reduction of voltage to 10,000 for transmission to their respective sub-systems.

The data upon which these municipal sub-stations have been worked out is given in previous Tables, in which are indicated the horse-power delivered to each station and sub-station. The sub-stations are considered as distinct from the distributing stations to follow, but in figuring operating costs these sub-stations are included as part of the line, and considered as being under the charge of the Operating Commission. A diagramatic plan, No. 4, is attached, showing a typical sub-station lay-out.

In the capital costs shown in Table 12, ample allowance has been made for land, foundations, buildings, switchboards, transformers, etc., at present prices, with an allowance of 10 per cent. for contingencies, 10 per cent. for business, legal and engineering expenses, and the usual interest and sinking fund charges during construction period.

Distributing Stations:

Distributing stations herein considered are such as would take the place of the present lighting and power stations in municipalities supplied, and in addition to what is already furnished by these present stations the power necessary to cover the entire demands of the municipality for all purposes, both municipal and private, it being considered in every case that the requirements of the municipality for arc and incandescent lighting will be the same, whether developments "A," "B" or "C" be considered; whereas, as regards the motor loads, these have been considered to be the difference between what is required for lighting and what is available under the three developments at the municipal switchboards. In other words, the lighting demands are constant for all developments; the motor load is considered as decreasing as the power delivered decreases. This is shown in Table 6 attached, in which Table is indicated the number of incandescent and arc lamps estimated upon as necessary, and the motor horse-power available for sale. As regards the motor loads, these have been obtained from a careful canvass of the seven municipalities. The incandescent and arc loads have been obtained wherever possible from the Lighting Companies. In certain cases it was impossible to obtain these direct from the Companies, in which cases other sources of information have been utilized, such as Government reports relating to electric lighting. In every case it has been considered that the distributing voltage in each municipality for incandescent lighting and motors is 2,200, and that arc lighting is done in accordance with modern practice by means of series alternating arc lamps, and the capital costs shown in Tables 13, 14, and 15 include the necessary distributing station, which is considered as being located immediately adjacent to the 60,000 volt sub-stations, with all the controlling switchboards, frequency changers, series arc transformers, etc., contained therein, together with the overhead distributing lines in the municipality and the necessary street transformers and meters for incandescent lighting and motor transformers for motor service, and also all series lines and arc lamps. In other words, the capital costs under these headings include everything necessary for the distribution of arc, incandescent, and motor power from the transmission substation in each municipality by overhead lines to the customers' premises, including meters and transformers, and service lines thereon, but not motors. In addition, the usual allowance of 10 per cent. for engineering, legal and business expenses; 10 per cent. for contingencies and interest and sinking fund for one year are added, it being considered that the whole construction period would be two years. A print, No. 5, is attached, showing diagramatically the lay-out of one of the Toronto sub-stations as an example.

Capital Costs Summary:

In Table 16 are given the total capital costs for developments "A," "B," and "C," these being a summary of previous Tables, and include, therefore, everything from the development at Niagara to the customers' premises in the case of the seven municipalities, and to the distributing stations of the eleven additional municipalities.

Capital Costs Apportionment to Municipalities:

In Table 17 the capital costs are apportioned between the municipalities affected as follows:—

(1) The total cost of development "A" and "B," respectively, including transmission and distribution, is apportioned between the seven municipalities directly represented in the Commission.

(2) The total cost of development "C," including transmission and distribution, in the case of the seven municipalities directly represented in the Commission, but excluding distribution in the case of the additional eleven municipalities, is also apportioned between them.

This apportionment has been made under the instructions of the Commission on the following principles:—

1st. That each municipality is chargeable with that proportion of the capital cost of the development at Niagara that the horse-power required by that municipality at Niagara Falls bears to the total requirements.

2nd. That each municipality is chargeable with the cost of the transmission lines which are common to all in proportion to the horse-power demanded by, and to the distance from Niagara of, that municipality.

3rd. That each municipality is chargeable with the total cost of any subsidiary transmission line which is installed solely for the use of that municipality.

4th. That each municipality is chargeable with its own sub-station equipment, buildings, land, etc.

5th. That each of the seven municipalities is chargeable with the total cost of its own distributing station and distributing system.

In Table 18 for convenience is shown the apportionment of the capital costs of development and transmission (only omitting the costs of distribution in the seven municipalities in which distribution has been considered previously), thus showing the amount of capital investment required, exclusive of distribution, separately from that required, inclusive of distribution.

Annual Costs of Power:

To determine yearly the cost of power under Developments "A," "B" and "C," for which the capital costs have been estimated as above, it becomes necessary to consider:—

1st. The capital charges, including interest and sinking fund.

2nd. Operating costs, including wages, supplies, repairs, etc.

3rd. Management and general expenses.

Interest:

Throughout this report it is assumed that bonds will be issued to cover the total capital costs shown, and under the instructions of the Commissioners the interest thereon has been taken at 4½ per cent. yearly; and it will be noted in previous Tables that the interest on bonds during construction has been charged to capital costs, and only after the plant is in operation is interest considered as chargeable to the yearly operating costs.

Sinking Fund:

The yearly costs have been charged with a sinking fund which will retire the bonds issued to cover capital expenditure in forty years. The Operating Commission will then have the original plant in good condition, free of debt, having retired all its bonds out of income.

Maintenance:

Maintenance is considered as being the amount necessarily spent in repairs to enable the plant to be kept in good operating condition to the end of the forty year period, for which bonds will have been issued, so that at the end of that period it may be operating in practically as good condition as when originally installed. The Municipal Power Works Act directs that improvements which may become necessary shall be made out of "general funds" in the event of such being available for the purpose, and, failing such, by the issue of "special bonds" to cover the cost thereof. Pursuant to this direction the operating costs have not been loaded with the capital cost of replacing plant, which, because of possible antiquation, may require to be replaced by newer types of apparatus. It is, however, believed that in the event of such expenditure being required the cost thereof will be returned to the "general" funds of the Operating Commission by the consequent saving in operating costs. Under these conditions various maintenance rates are assumed on the capital costs, from 1½ per cent. on hydraulic developments and buildings, and 5 per cent. on running machinery, switchboards, etc., up to 10 per cent. on arc lamps, etc., and the amounts derived thereby are as shown in the Tables.

Supplies:

Supplies in every case are a pure estimate, based upon experience, and sub-divided under the different items in accordance with fairly well-known practice. The larger items, such as carbons and lamps, can be figured quite closely. The smaller items, such as oil, waste, etc., are approximated.

General Expenses:

General expenses have been considered as including all remuneration and expenses for salaries, general office expenses, travelling expenses, etc., which cannot be apportioned definitely to any particular section, and which, therefore, must be split up in certain arbitrary ways, so that each service shall be chargeable with a fair amount. The loading for salaries is sufficient to cover a business-like allowance for Operating Commissioners.

Wages:

Wages are taken at the current rates for all classes of service, and apportioned between the different demands, according to their requirements; and, generally speaking, it may be said that each service has its own wage list pretty clearly defined, so that it is possible to separate accurately the charges under this head for the separate service, such as development, transmission and distribution, and to apportion the latter to arc lighting, incandescent lighting and motor service.

It will be seen, therefore, that all the items entering into the cost of power are properly sub-divided among the different services, and that practically only general expenses have to be divided in an arbitrary way between these services.

The yearly costs are calculated under two main heads, viz.:—

1st. Those arising out of the development and transmission of power, operation of sub-stations, etc.

2nd. Those arising out of the individual, municipal, subsidiary distribution, and which are divided between arc, incandescent and motor services.

As regards the management costs for the development and distribution, these are also distributed in what is considered a fair way between the development and distribution services. It is, therefore, possible to separate the yearly charges at Niagara Falls for power from those at the municipal sub-stations. The Tables below are arranged so as to indicate clearly the costs of power per horse-power year as follows:—

1st. At the outgoing terminals of the generating station at Niagara.

2nd. At the outgoing terminals of the sub-stations at the municipalities.

3rd. At the consumers' premises in the municipalities for arc, incandescent, and motor services.

Annual Costs at Niagara Plant:

In Table 19 is shown the annual costs of power at Niagara under Developments "A," "B" and "C," the whole figured on the general lines indicated above for operating and fixed charges. The only special item claiming attention is that pertaining to the rental of power. As mentioned previously, the Park Commissioners have established standard rates per horse-power for all power developed within the boundaries of the Park, and we have loaded these costs with the same rental that is paid by the present Companies already established at Niagara. These rentals are as follows, and are taken from the published agreement between the Queen Victoria Niagara Falls Park Commissioners and the Ontario Power Co., of Niagara Falls:—

Up to 10,000 H.P. minimum rate of $15,000 per year.

2nd. 10,000 H.P., $1 per electrical horse-power per year.

3rd. 10,000 H.P., 75 cents per electrical horse-power per year.

4th. 10,000 H.P., and all subsequent power, 50 cents per electrical horse-power per year.

From these figures the third line in Table 19 has been computed. The totals shown in that Table indicate the yearly cost of operation,, not only of the water-power station at Niagara, but of its 60,000 volt sub-station, situated on the bluff, within 1,000 feet of the hydraulic development, which is considered throughout this report to be a part of the development, and the expenses of the Operating Commission.

Annual Costs, Transmission Lines and Sub-Stations:

Table 20 indicates the yearly operating costs for, and fixed charges on, the transmission lines and step-down sub-stations at the various municipalities, wherein the transmitting voltage is reduced from 60,000 to 2,200 for distribution in the smaller municipalities to 10,500 for distribution to the transformer sub-stations in Toronto, and to 10,000 for the subsidiary transmission lines surrounding Stratford and Guelph, together with the fixed and operating costs chargeable to the 10,500 volt sub-distribution in Toronto, and the 10,000 volt distribution from Guelph and Stratford. These items cover all the necessary wages for maintenance and inspection of these lines, for the operation staffs at sub-stations, with the proper allowance for supplies, and a fair allowance for general expenses, but include no allowance for the municipal distribution, which is treated separately in tables to follow.

Annual Costs Distribution Plants:

In Tables 21, 22 and 23 are shown the annual charges involved in distributing power and light to consumers. To these charges the cost of power at the outgoing lines of the 60,000 volt station, to which the municipal station is immediately adjacent, must be added. Entirely new distributing systems as already explained are assumed, no consideration being given to any existing distributing system in such municipalities. Consumers, therefore, are chargeable with fixed charges on an entirely new and modern distributing plant, and the operating costs of same based on modern conditions. These costs are apportioned accurately between the different services, except in the case of management and some wage expenses, which have been apportioned arbitrarily as appeared fair.

It is understood, therefore, that these tables above-mentioned indicate merely the annual costs of operating the distributing systems apart from the cost of power at end of transmission line, that cost being added in later tables.

THE HON. ADAM BECK, M.P.P.
London, Ont.

It will be noted also that, for reasons already given, distribution costs have only been figured for the seven municipalities represented in the Commission.

Arc Lighting:

In Table 21 are shown the total annual distributing costs for arc lighting apart from the cost for power. They include the fixed charges upon such apparatus as is devoted exclusively to their use in the streets and sub-stations, and a fair apportionment of such apparatus as is used in common for all services, such as switchboards, etc.

In the operating costs are included a fair apportionment of general expenses and common wages, together with an allowance for trimming, carboning and repairs to arc lamps, and in the item "supplies" is included carbons, globes, and small supplies.

It is assumed that an all-night service of 480 watt series alternating current lamps is furnished in accordance with modern practice.

Incandescent Lighting:

The annual cost of this distributing service for seven municipalities only are shown in Table 22, which does not include the cost of power, this appearing in later Tables.

The fixed charges have been estimated on such apparatus as is entirely chargeable to the incandescent service and proportionately to the investment in apparatus common to all services. The same remarks apply to wages and general expenses.

Supplies include incandescent lamps which are assumed to be replaced free of charge by the municipality.

Maintenance has been allowed for very liberally, owing to the rapid deterioration of poles, wire insulation, house service and meters.

In the above it is assumed that a 24-hour service is maintained.

Annual Motor Power Distributing Costs.

In Table 23 is shown for the three developments the annual costs for distributing motor power throughout the municipality. As previously stated, the actual cost of power is not included herein and the sale of motor power is considered to be the difference between the power laid down at the municipal sub-station under the three developments, and that required for arc and incandescent demands, which are assumed to be fixed and identical for each development.

The justification for the above assumption is to be found in the fact that whether a large or small amount of power be purchased by the municipality, a definite amount is necessary to accommodate the present arc and incandescent lighting, and only the remainder is available for sale to motor users. It is assumed that all motor power will be operated at 25 cycles, thus eliminating the use of frequency changers for this service.

Copper and transformers for distribution, therefore, are kept separate; the fixed charges on these being charged to motor service costs direct. In the case of apparatus common to all services, fixed charges, of course, are divided, generally speaking, in proportion to the horse-power required for the several services.

Total Annual Costs of Power:

From the preceding Tables relating to capital costs and annual operating charges, the total costs of power are given in Tables 24, 25, 26, 27 and 28 for:—

1st. The cost of power at Niagara.
2nd. The cost of power at the transmission sub-station at the municipality.
3rd. The cost of arc lighting at the lamps in the municipality.
4th. The cost of incandescent lighting at customers' premises.
5th. The cost of power at motor terminal.

The first two Tables refer to eighteen municipalities. The three latter Tables, relating to distribution, refer only to the seven at present interested.

The yearly costs per horse-power, shown in Table 24, are obtained from the annual costs at Niagara, divided by the horse-power available at the outgoing terminals of the Niagara Plant. Those in Table 25 are obtained by adding the annual total costs at Niagara, as per Table 24, to those of transmission calculated on the principle stated in a footnote to the Table itself.

Tables 26, 27 and 28 are obtained by adding to the annual distributing costs, the amount obtained by multiplying the maximum demands of those services by the annual cost of the power and reducing the result to the various unit bases adopted.

It will be noted that in none of the above has any consideration been given to the possibility of over-sale of power. This will occur in practical operation tending to reduce somewhat the cost thereof, and it appears probable that the Commissioners, in view of overlapping demands, could probably sell 25 to 33 per cent. more power than is actually developed. Further, it should be noted that all electrical machinery herein figured upon has a capacity for at least 25 per cent. over-load, so that under any condition of operation with the equipment estimated upon, there is an ample allowance throughout to enable one or more units of equipment to be shut down for repairs.

Total Annual Costs of Power if Site No. 3 at Niagara Falls be Developed instead of Site No. 4.

Pursuant to the "Special Note," submitted on pages 8 and 9 herein, we beg to say that while hitherto Site No. 4 only has been considered, and the costs shown in previous tables refer only to the development of that site, it is now deemed advisable to insert in this report an additional set of tables showing the yearly costs of operation should Site No. 3 be developed instead of Site No. 4. This provides for any contingencies that may arise which would render it inadvisable to develop Site No. 4.

By referring to Table No. 8 it will be seen that the development of any other site than No. 4 involves a considerable increase in capital costs at Niagara, and in consequence an increase in the fixed charges, thus increasing the yearly cost of operation; but no changes in actual operating costs are required. In the Tables to follow account has been taken of the additional interest, sinking fund and maintenance charges, and the whole amount thereof is carried forward to the costs at customers' premises. This is shown clearly in Tables Nos. 29, 30, 31, 32 and 33 following, and the notes on pages 22 and 23 referring to Tables 24, 25, 26, 27 and 28 apply equally to these.

Rates for Power and Light.

From the preceding Tables it will be seen that the costs of power vary with the amounts of power required in the different municipalities, as well as with their distance from the source of supply, and in certain instances it will be noted that the limit of economical distribution has been about reached for the special conditions which exist in this district. It may be confidently anticipated that within the next few years many of the branch lines, and probably some of the through lines, of railway will be electrified, thus furnishing an additional market for power beyond that herein considered; also that the development and sale of power at reasonable rates will tend to build up this section as a manufacturing district, to the consequent benefit of the power undertaking. We have, however, dealt only with the actual facts relating to the conditions which exist, and have made no attempt to discount the future; but it may be predicted with confidence that, under the actual existing conditions, the cost of power will not be in excess of the prices given, and in the future they will be reduced as the above prospects are realized.

In dealing with the question of rates, consideration ought to be given to actual commercial conditions and not exclusively to the actual estimated costs set forth in these Tables, which should merely be considered as a basis from which rates are to be struck, and not the rates themselves. Rates for arc lighting are not fixed by what arc lighting actually costs, this being unknown to the Company itself in many cases, but vary in each locality, depending upon the number of lights contracted for; the need, urgent or otherwise, of the municipality; the strength of the operating company; and very largely, too, with the costs of lights furnished to other municipalities in the immediate vicinity. Similarly, incandescent rates are not fixed in accordance with what incandescent lighting actually costs, but at a figure at which they will yield greatest returns, avoiding, on the one hand, the discouraging of use by excessive rates, and on the other hand, the installation of excessive plant to take care of unremunerative business obtained at too low rates.

As regards the cost of power for motors, this is usually determined very largely by the condition existing in each particular customer's premises, and generally by what price he can afford to pay, the endeavor being to consider each case on its own merits, and to give such a rate as will entice the prospective customer to abandon the use of his steam power. It is, therefore, not possible to discuss rates other than those given, which indicates what should be charged to repay all the expenses of development, generation, transmission and distribution.

Whether the development and distribution only are in the hands of the Operating Commission, and the local distribution in the hands of each municipality, or whether all alike are in the hands of the Operating Commission, the question of the local rates for lighting and power should be determined by an accurate knowledge of local conditions and present rates. The cost per horse-power at each municipality has, however, been definitely calculated as indicated in the Tables.

Cost of Steam Power:

In view of the contemplated transmission of electrical power it becomes pertinent to enquire what are the costs of developing power through prime movers, such as gas and steam engines. Inasmuch as any general statement of the costs of steam power is of little or no value, without knowing the local conditions, in order to present figures relating to this matter, it becomes necessary to study the conditions which are prevalent in the district. By our canvass of the manufacturers in the seven municipalities, we are enabled through reports received to determine the general character of the steam plants installed; the hours of work; the rates of wages for engine-room staffs; the costs of coal, etc., and are, therefore, able to present with this report an estimate of yearly cost per horse-power, based upon conditions which are general throughout the district in question.

It is not to be anticipated that the costs given will fit any particular case, but if it were possible to average all the results of steam power costs for each size of plant throughout the district, we would expect the costs to be about the same as averaged while differing widely from the extreme cases met with, which extremes are due to abnormal conditions of load and service.

The tendency of the steam user is always to minimize the costs of his power. This arises from his practice of leaving out factors which are important. It will generally be found that his estimate is based upon the addition of wages, coal, and sometimes oil and supplies, and the division of the yearly costs so found by the rated horse-power of his plant, while in addition, interest, depreciation and repairs are also chargeable to the cost, and that not only upon the plant itself, but upon the buildings and land upon which it is built.

Further, it is frequently found that while any particular plant under consideration may be of 100 H.P. capacity, its average load is much less; say, 50 H.P., for illustration. This fact alone, apart from any other, immediately doubles the yearly cost as compared with an estimate made, based upon the rated horse-power of the engines. It is therefore necessary to consider not only the cost of power developed from steam at the rated horse-power of the engines, but also at the indicated horse-power of load found to exist in the average plant used for industrial purposes apart from those large users, such as electric light, street railway and pumping stations.

A separation has, therefore, been made of Class B in Table 2, which deals chiefly with steam plants used for industrial purposes, and it has been found for this class of service, which represents the average manufacturer throughout the district more accurately than any other, that while the rated indicated horse-power of engines installed is 24,779, the actual present loads are 19,122, indicating that on the average these industrial plants require only 75 per cent. of the power which their engines are capable of developing, based upon their rated horse-power. We have, therefore, assumed in the Tables of steam cost these average conditions, but to meet that case where the engines are fully loaded, we have, as an addition to this load factor, assumed one of 100 per cent., wherein the actual indicated horse-power and the rated indicated horse-power are the same.

Basal Conditions:

It has been found in this district the following general conditions exist, and upon these conditions Tables are based:—

Average working days per year, 305 of 10 hours each.
Average price of coal on the boiler-room floor, per ton, $4.
Average rates of wages for boiler and engine-room staffs, from $300 to $1,200 per year.
Steam pressure, from 60 to 150 pounds.
Average load factor, 75 per cent.
Engine speeds, 80 to 300 revolutions per minute.
Types of engines, simple slide valve, up to the compound condensing Corliss types.
Evaporation of water per pound of coal, 7 to 9 lbs.
Buildings, from galvanized iron to solid brick.
Smoke stacks, iron or brick.

It will be seen from the above that there is a wide range in conditions, but, generally speaking, it will be found that the cheaper construction and less efficient plant is confined to the smaller sizes. At one end of the scale will be found small plants having slide valve engines of uneconomical types, with cheap fire-tube boilers, iron smoke stacks, cheap buildings, and at the other extreme the largest plants will be found to have compound condensing engines, with water-tube boilers, high--pressure steam and substantial brick buildings, so that, all these being taken into account and the quality of the buildings and apparatus graduated in proportion to the size of the plant, a fair average results.

Table 34 shows in the first column the horse-power of the plants estimated upon, ranging from 10 indicated horse-power to 750 indicated horse-power in engines. This horse-power relates, so far as engines are concerned, to single units of the above sizes, while, so far as boilers are concerned, the estimate is based upon a boiler capacity sufficient to supply the indicated horse-power of the engines, at the rated horse-power of the boilers, which vary from one to three in number, as plants increase in size, the larger plants having water-tube boilers, the smaller plants fire-tube boilers.

In the second column of Table 34 is shown the yearly cost of operation for 305 days of 10 hours each at full rated load, with coal at $4 per ton on the boiler-room floor. The figures given include the following:—Coal, wages, supplies, depreciation, repairs and interest. Interest has been assumed at 5 per cent., depreciation from 2 per cent. for buildings to 10 per cent. for small boilers and pipes, but graduated throughout according to the size and original excellence of the plant.

In the third column of Table 34 is shown the cost per horse-power year with the engines operating at three-quarters load, this being the average condition found to exist throughout the district, the figures being derived in the same way as those for the rated loads in column two, with the addition of the extra coal required when operating under smaller load. It must be carefully noted that these figures refer, for example, to 75 load horse-power derived from a 100 horse-power plant, while those in column 2 indicate the cost per horse-power year if 100 horse-power be obtained from the same plant.

Gas Plant Power Costs:

Although, as shown by the Tables, there are few gas engines in existence in this district, it should be borne in mind that the gas engine as a prime mover, when operated from its own gas-producer plant, is becoming a factor in the power problem, one which will have to be faced, and which will tend to limit the economical range of transmitted power, as the cost of operation is decidedly less for most conditions of load than steam power. In this connection we do not refer to the small gas engines at present operated to a certain extent by gas purchased from the gas companies, but to gas engine plants making their own producer gas from their own producer plant. Inasmuch as the gas engine will develop from one pound of coal the power that the best and most economical type of steam engine in this district will not produce for less than two pounds, it is evident that great economies in fuel consumption will result in their adoption. Fuel-saving, however, is not the whole of the story, as the initial cost of gas engine and producer plant for sizes under 100 horse-power is, generally speaking, greater than for steam plants of the usual types installed. This last condition, while true at the present time in a general way, may not hold good for long, and it may be anticipated that in the not distant future, a gas engine plant, consisting of producer and auxiliary plant and gas engines, may be purchased for about the same price as a first-class steam plant. The results also of operation of the newer type of gas engines are such as to indicate that the reproach of unreliability from which those of smaller sizes at least have hitherto suffered is about to be removed, and the gas engine operating by producer gas may well be reckoned with as a factor in determining the cost of power. For this reason the attached Tables of estimated yearly costs per brake horse-power are given, although not with the same confidence as in the case of steam costs, as the capital costs of the gas plants, being but newly introduced into this country, are very uncertain, installations of all weights, sizes, reliability and costs being offered to perform the same duties, so that the selection of a gas plant to meet certain conditions of operation is by no means an easy one. It might also be stated that while the gas engine at its full rated load is much more efficient than the steam engine, at partial loads its operation is not attended with the same economies; and in fact, on one-half load or less, generally speaking, the steam engine is the more economical of the two. Further, it should be remarked that while the modern steam engine has an overload capacity of from 25 to 50 per cent., with as nearly as good economy as at full load, the gas engine has practically no overload capacity that can be depended upon, so that where peaks of, say, 25 per cent. overload exist, 100 per cent. of steam equipment will meet this demand, whereas it will require 125 per cent. of gas engine equipment.

In Table 35 attached is shown a comparison of the yearly cost per brake horse-power of operating steam and gas engines, both at full load and at three-quarters load.

Figures relating to size are derived from the preceding Table in which the indicated horse-power only was considered, as this lends itself to the direct comparison of the costs of power obtained by electric motor driving. In this Table, however, owing to the fact that the indicated horse-power is a very uncertain matter with a gas engine, which is or should be rated at its brake horse-power, the cost per brake horse-power year of steam plants are given in preference to the indicated horse-power of the preceding Tables, so that they are directly comparable with the gas plants on brake ratings. It may be explained that the indicated horse-power is measured by the amount of steam given to the engines, while the brake horse-power is what an engine delivers at its pulley to the belting, the difference being losses involved. The figures for gas plants have been compiled upon the same basis in a general way as those of the steam engines, and include the necessary gas producers, scrubbers, washers and auxiliary plant. The necessary buildings also have been included, and the endeavor has been in every way to make these Tables comparative.

The cost of gas plants, as mentioned before, fluctuates widely, but in this case they have been computed upon fair average prices for thoroughly reliable plants and the fixed charges computed therefrom.

It has been assumed in both the steam and gas figures that no cost is chargeable for water, as in general this is obtained from rivers or wells, and only involves the cost of pumping.

(Signed). ROSS AND HOLGATE.

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Table 1.

Horse Power Ratings of Plants Installed.

Seven Municipalities.

Municipality.	Boilers.	Engines.	Generators.	Motors.	Gas Engines.	Average Load.	Future Average Load.
Toronto and Suburbs	74,380	55,577	24,228	10,825	219	53,364	65,078
London..................	9,865	7,097	2,575	769	34	6,457	6,633
Brantford...............	5,379	4,696	830	861	9	4,275	4,465
Guelph	5,590	3,828	770	258	...	3,303	3,860
Stratford	3,120	2,877	860	232	..	2,428	3,029
Woodstock.............	3,355	2,672	......	24	18	2,120	2,724
Ingersoll................	1,717	1,845	375	294	...	1,684	2,094
Total...............	103,404	78,592	29,638	13,263	280	73,631	87,883

The above table shows rated indicated horse power of apparatus at present operating in the seven municipalities, from actual canvass. Average loads are obtained from estimates of owners, or engineers in charge, from indicator and load diagrams in some cases, and from watt meter readings in others. "Future Average Load" indicates the owners anticipation of increases within two years.

Table 2.

Available Power Market Seven Municipalities.

Municipality	Class "A"	Class "B"	Class "C"	Class "D"	Class "E"	Total
Toronto and Suburbs......	6,547	11,246	21,810	1,158	103	40,864
London	462	1,260	2,520	193	23	4,458
Brantford	440	862	1,455	290	......	3,047
Guelph	300	877	870	357	......	2,404
Stratford	229	1,400	210	145	......	1,984
Woodstock	24	668	510	262	9	1,473
Ingersoll	294	367	540	125	......	1,326
Total............	8,296	16,680	27,915	2,530	135	55,556

The above table indicates available power market or the estimated loads available to the Transmission Commission, divided as follows :—

Class A.—Those using electric motors exclusive of street railway motors, rotary converters, etc.

Class B.—Industrial plants using steam for power only, developed from coal and operating generally ten hours per day. This covers a majority of manufacturing plants.

Class C.—Public service plants such as electric light, street railway and pumping stations, operating 24 hours.

Class D.—Special industrial plants using steam for power and other purposes and in some cases burning refuse.

Class E.—Gas and oil engine plants.

Each plant and class is considered by itself as to its probable acceptance of transmitted power. A certain proportion of each class is included in the table ; that proportion being calculated according to the probability of a substantial saving being made by the use of transmitted power. To avoid including motor loads in class A under generator loads, these have been deducted from Class C.

Table 3.

Power Market Considered Available in Eighteen Municipalities.

Municipality.	Populat'n.	No. Mfrs.	Net Power Required Delivered.	Remarks.
Toronto and Suburbs	208,040	847	40,200	The figures for these municipalities wereobtained from actual canvass.
London	37,976	120	4,690	
Brantford	16,619	44	3,331	
Guelph	11,496	68	2,412	
Stratford	9,959	42	2,012	
Woodstock	8,833	40	1,340	
Ingersoll	4,573	23	1,340	Tot. 55,325
Hamilton	52,634		13,400	The figures for these municipalities wereobtained from a comparison with Brantford, Guelph, Stratford, and Woodstock, and from Government reports.
St. Thomas	11,485	50	2,680	
Paris	3,229	23	1,072	
Dundas	3,173	17	670	
Mitchell	2,000	9	402	
St. Mary's	3,384	17	670	
Berlin	7,425	68	3,218	
Waterloo	3,537	27	1,274	
Preston	2,308	15	670	
Hespeler	2,247	6	268	
Galt	7,866	31	1,476	Tot. 25,800
Totals	396,784		81,125	81,125

Table 3 developed from Table 2 indicates the available market in not only the seven interested municipalities, but in eleven additional, with a population of 2,000 or over, within easy distance of the lines of the original seven. No canvass was made for the eleven additional municipalities, but requirements indicated are based on the number of manufacturers as compared with those in the original seven.

Table 4.

Basis of Required Hydraulic Developments	Development "A"	"B"	"C"
Municipalities supplied	7	7	18
Proportion of the available market covered	50%	100%	100%
Horse power delivered	27,662	55,325	81,125
Horse power required at generating station terminals at peak of load	33,000	66,000	100,000
Nominal rating used to distinguish developments	30,000	60,000	100,000

The above Table indicates the requirements under three considerations :—

1st —Development "A" considering that only half the available market of seven municipalities was obtained.

2nd—Development "B" that the full available market for seven municipalities was obtained.

3rd—Development "C" that the whole available market of eighteen municipalities was obtained.

Developments "A," "B," and "C" are in Tables to follow, designated as 30,000 60,000 and 100,000 horse power nominal developments.

Table 5.

General Data—Generating Plant

	Development "A"	"B"	"C"
Normal capacity of generating plant	30,000	60,000	100,000
Maximum capacity of generating plant	37,500	75,000	125,000
Number of units of wheels and generators	3	6	10
Number of units of exciters and wheels	2	3	4
Transformers, No. of units	9	18	30
Proportion of switchboards, etc., installed	30%	60%	100%

Voltage of generators	12,000	12,000	12,000
Voltage of outgoing lines	60.000	60,000	60,000
Frequency of system	25	25	25

The above is a general table giving the physical data of the contemplated developments, number and size of generating units, etc.

Table 6.

Distribution Data—Requirements for Lighting & Motor Service.

	Development "A" 30,000 Horse Power				
Municipality	No. o Arc Lamps	No. of Inc. Lamps	H. P. required for all Lighting	H. P. available for sale	Total H. P. required
Toronto	1,600	160,000	9,962	10,138	20,100
London	400	27,500	1,950	395	2,345
Brantford	120	16,000	1,020	646	1,666
Guelph	150	6,000	487	719	1,206
Stratford	91	6,000	428	578	1,006
Woodstock	80	4,500	360	310	670
Ingersoll	40	4,000	265	405	670

	Developments "B" & "C" 60,000 & 100,000 H. P.				
Municipality	No. of Arc Lamps	No. of Inc. Lamps	H. P. required for all lighting	H. P. available for sale	Total H. P. required
Toronto	1,600	160,000	9,962	30,238	40,200
London	400	27,500	1,950	2,740	4,690
Brantford	120	16,000	1,020	2,311	3,331
Guelph	150	6,000	487	1,925	2,412
Stratford	91	6,000	428	1,584	2,012
Woodstock	80	4,500	360	980	1,340
Ingersoll	40	4,000	265	1,075	1,340

Note.—For the eleven additional municipalities no division of distribution requirements has been made.

From the canvass made is deduced the power required in seven municipalities for arc and incandescent lighting; the horse power available for sale for motors being the difference between what is required for lighting and the total laid down at the municipalities.

Note that lighting is considered as being a fixed quantity for all developments.

Table 7.

Capital Costs—Niagara Plant.

Items	Development "A" 30,000 H.P.	Development "B" 60,000 H.P.	Development "C" 100,000 H.P.
Hydraulic Development	$1,134,620	$1,151,620	$1,173,620
Station and Buildings	120,000	160,000	308,000
Water Wheels and Accessories	309,375	618,750	1,031,250
Generators	173,250	346,500	577,500
Transformers	132,000	264,000	440,000
Switchboards	60,000	90,000	165,000
Ducts and Cables	20,000	25,000	50,325
Cranes and Auxiliaries	15,000	20,000	27,500
Miscellaneous	40,000	50,000	82,500
	$2,004,245	$2,725,870	$3,855,695

Brought forward	$2,004,245	$2,725,870	$3,855.695
Engineering and Business 10%	200,424	272,587	385,569
Total Cost of Construction	$2,204,669	$2,998,457	$4,241,264
Interest, 1½ years, 4½%	162,337	220,785	312,296
Sinking Fund	37,972	51,645	73,052
Total Capital Outlay	$2,404,978	$3,270,887	$4,626,612

Note.—Due allowance for contingencies has been made in each item of capital costs.

The above Table indicates the capital costs of the three developments at Niagara, considering that the hydraulic development is made for 100,000 H.P., and the machinery and buildings are installed and constructed as required to suit developments for 30,000 H.P. and 60,000 H.P.

Table 8.

Comparative Cost of Developing Various Sites at Niagara Falls.

	Site No.	Tunnel Length (feet)	Total Capital Outlay Required*	Increased Cost Over Site No. 4
Estimate "A"				
30,000 Horse Power	1	6.220	$3,880,695	$1,475,717
	2	5,450	3,683,656	1,278,678
	3	4,300	3,389,451	984,473
	4	400	2,404.978	—
Estimate "B"				
60,000 Horse Power	1	6,220	4,741,662	1,470,775
	2	5,450	4,544,622	1,273,735
	3	4,300	4,250,376	979,489
	4	400	3,270,887	—
Estimate "C"				
100,000 Horse Power	1	6,220	6,089,648	1,463,036
	2	5,450	5,892,608	1,265,996
	3	4,300	5,598.405	971,793
	4	400	4,626,612	—

*These capital costs were obtained similarly to those shown in Table 7.

Table 9.

Capital Costs—Transmission Lines—Development "A"—30,000 Horse Power.

Items.	Niagara-Toronto Line.	Niagara-London Line.	Total Cost of Both Lines.
Right of way	$140,000	$250,500	$390,500
Towers	129,600	270,540	400,140
Insulators	14,400	15,030	19,430
Copper	224,868	145,883	370,751
Lightning Arresters	11,000	8,800	19,800
60,000 V. Switches	16,000	13,000	29,000
Telephone line	22,240	46,426	68,666
	$558,108	$750,179	$1,308,287
Contingencies, 10%	55,811	75,018	130,829
Engineering and Business, 10%	55,811	75,018	130,829
Total Cost of Construction	$669,730	$900,215	$1,569,945
Interest 4½%, one year	31,909	42,891	74,800
Sinking Fund, one year.	7,464	10,033	17,497
Total Capital Outlay	$709,103	$953,139	$1,662,242

The above Table indicates the capital cost of transmission lines for 30,000 H.P. to seven municipalities for half market, divided into two services; one terminating at Toronto and supplying Toronto only; and one to London, covering the requirements of the six other municipalities.

Table 10.

Capital Costs—Transmission Lines—Development "B"— 60,000 Horse Power.

Items	Niagara-Toronto Line	Niagara-London Line	Total Cost of both Lines
Right of Way	$ 216,000	$ 250,500	$ 466,500
Towers	259,200	270,540	529,740
Insulators	28,800	30,060	58,860
Copper	449,736	291,766	741,502
Lightning Arresters	22,000	15,400	37,400
60,000 V. Switches	32,000	25,000	57,000
Telephone Line	22,240	46,426	68,666
	$1,029,976	$929,692	$1,959,668
Contingencies 10%	102,997	92,969	195,966
Engineering and Business 10%	102,997	92,969	195,966
Total Cost of Construction	$1,235,970	$1,115,630	$2,351,600
Interest 4½% one year	58,888	53,155	112,043
Sinking Fund one year	13,775	12,433	26,208
Total Capital Outlay	$1,308,633	$1,181,218	$2,489,851

The above Table indicates capital costs of transmission lines for 60,000 H.P. for seven municipalities for full market; Toronto line terminating at Toronto for Toronto demands only; London line terminating at London for the uses of the six other municipalities.

Table 11.

Capital Costs—Transmission Lines, Development "C," 100,000 H.P.

Items.	Niagara-Toronto Line.	Niagara-London Line.	Stratford Sub-System.	Guelph Sub-System.	Total.
Extra Building and Apparatus (60,000 and 100,000 V.)			$ 10,134	$ 54,825	$ 64,959
Right of Way	$ 216,000	$ 328,500	24,000	28,000	596,500
Towers	259,200	403,515	10,800	19,080	766,230
Insulators	28,800	44,835			
Copper	449,736	433,718	9,765	108,150	1,001,369
Lightning Arresters	22,000	35,200	1,800	6,300	65,300
60,000 V Switches or 100,000 V Switches	32,000	44,000	700	700	77,400
Telephone Line	22,240	50,040	1,505	1,756	75,541
	$1,029,976	$1,339,808	$58,704	$218,811	$2,647,299
Contingencies, 10%	102,997	133,980	5,870	21,881	264,729
Engineering and Business, 10%	102,997	133,980	5,870	21,881	264,729
Total Cost Construction	$1,235,970	$1,607,770	$70,444	$262,573	$3,176,757
Interest, one year 4½%	58,888	76,603	3,356	12,510	151,357
Sinking Fund, one year	13,775	17,919	785	2,927	35,406
Total Capital Outlay	$1,308,633	$1,702,292	$74,585	$278,010	$3,363,520

The above Table indicates the capital costs of transmission lines for 100,000 H.P. to eighteen municipalities for full market, and includes sub-systems of distribution from Guelph and Stratford, as indicated on Map No. 2. The St. Thomas extension is included in the Niagara-London line estimate.

Table 12.

Capital Costs—60,000 V. and 10,000 V. Substations.

Municipality.	Development "A" 30,000 H.P.	Development "B" 60,000 H.P.	Development "C" 100,000 H.P.
Niagara-Toronto System—			
Toronto	$747,485	$1,112,485	$1,112,485
Niagara-London System—			
London	40,180	70,007	70,007
Brantford	30,302	49,170	49,170
Guelph	16,072	28,650	28,650
Stratford	16,072	28,650	28,650
Woodstock	11,417	18,468	18,468
Ingersoll	11,417	18,468	18,468
Hamilton	....	....	139,760
St. Thomas	....	....	34,685
Paris	....	....	18,628
Dundas	....	....	13,863
Stratford Sub-system—	Not in 30,000 Development	Not in 60,000 Development	
Mitchell			9,593
St. Mary's			11,498
Guelph Sub-system—			
Berlin			35,130
Waterloo			20,392
Preston			11,943
Hespeler			6,352
Galt			23,251
Totals	$872,945	$1,325,898	$1,650,993

The above Table indicates the capital cost of transmission sub-stations in eighteen municipalities.

Development "A" for seven municipalities only at half market.

Development "B" for seven municipalities only at full market.

Development "C" for eighteen municipalities at full market.

Table 13.

Capital costs of Municipal Distributing Plants Arc Lighting
(2,200 V. Distributing Station, arc lamps and lines)

Municipality	Development "A" 30,000 H. P.	Development "B" 60,000 H. P.	Development "C" 100,000 H. P.
Toronto & Suburbs	$196,463.00	$196,463.00	$196,463.00
London	43,112.00	43,112.00	43,112.00
Brantford	14,016.00	14,016.00	14,016.00
Guelph	16,439.00	16,439.00	16,439.00
Stratford	11,274.00	11,274.00	11,274.00
Woodstock	11,058.00	11,058.00	11,058.00
Ingersoll	6,985.00	6,985.00	6,985.00
	$299,347.00	$299,347.00	$299,347.00

The above Table indicates capital costs of arc lighting distribution throughout seven municipalities, including share of distributing stations, arc lamps and lines for three developments.

Table 14.

Capital Costs of Municipal Distributing Plants, Incandescent Lighting.
(2,200 V. Distributing Station to Customers' Meters.)

Municipality	Development "A" 30,000 H.P.	Development "B" 60,000 H.P.	Development "C" 100,000 H.P.
Toronto and Suburbs	$669,691	$669,691	$669,691
London	178,520	178,520	178,520
Brantford	84,445	84,445	84,445
Guelph	47,959	47,959	47,959
Stratford	45,902	45,902	45,902
Woodstock	40,950	40,950	40,950
Ingersoll	39,265	39 265	39,265
	$1,106,732	$1,106,732	$1,106,732

The above Table indicates capital costs of distributing plants for seven municipalities for incandescent lighting, including share of distributing station, distributing lines in the municipality, customers' transformers, connections and the necessary frequency changers.

Table 15.

Capital Costs of Municipal Distributing Plants Motor Service.
(2,200 V. Distributing Station to Customers' Meters).

Municipality	Development "A"	Development "B"	Development "C"
Toronto & Suburbs	$240,037	$584,033	$584,033
London	22,859	83,003	83,003
Brantford	14,513	52,382	52,382
Guelph	17,113	46,950	46,950
Stratford	16,173	36,571	36,571
Woodstock	12,462	27,745	27,745
Ingersoll	15,130	31,212	31,212
	$338,287	$861,896	$861,896

The above table indicates the cost of distributing systems in the municipalities for motor service estimated as being delivered from separate lines and including share of distributing station service transformers and connections, but not motors.

Table 16.

Capital Costs—Summary.

Items	Development "A" 30,000 H.P.	Development "B" 60,000 H.P.	Development "C" 100,000 H.P.
Niagara Plant	$2,404,978	$3,270,887	$4,626,612
Transmission Lines	1,662,242	2,489,851	3,363,520
Sub-stations 60,000 V. & 10,000 V.	872,945	1,325,898	1,650,993
Total	$4.940,165	$7,086,636	$9,641,125
Additional Costs of Distributing Stations and Lines	1,744,464	2,267,975	2,267,975
Grand Total	$6,684,629	$9,354,611	$11,909,100
Estimates in distributing plants only made for seven municipalities.			
N.B.—Additional cost to above if development made at site 3, as per Table No. 8	984,473	979,489	971,793
	$7,669,102	$10,334,100	$12,880,893

The above Table indicates a summary of capital costs of the three developments. Development "A" for seven municipalities for half market to the consumers' premises. Development "B" for seven municipalities for the full market to the consumers' premises.

Development "C" for eighteen municipalities for the full market to the outgoing terminals of the municipal sub-station, but not including distribution costs for the eleven additional, as no distribution costs have been worked out for these.

N.B.—The data furnished in other tables and in the body of the report in connection with the eleven additional municipalities was voluntarily collected and computed by us. We could not, however, work out the distributing costs in these municipalities without incurring an unjustifiable additional expense and delay.

Table 17.—Part 1.

Site 4—Total—Capital Costs—Apportionment to Municipalities.

Municipalities	Development "A" 30,000 H.P.	Development "B" 60,000 H.P.	Development "C" 100,000 H.P.
Niagara-Toronto System—			
Toronto	$4,323,096	$6,265,424	$6,216,137
Niagara-London System—			
London	847,119	1,095,356	945,185
Brantford	429,152	571,097	509,248
Guelph	317,441	425,386	377,821
Stratford	329,923	431,018	368,154
Woodstock	216,226	278,939	244,589
Ingersoll	221,672	287,391	249,754
			$8,910,888
Hamilton			1,163,812
St. Thomas			399,438
Paris			123,322
Dundas			66,359
Stratford Sub-System			
Mitchell		N.B.—These items do not include distribution.	97,847
St. Mary's			130,136
Guelph Sub-System			
Berlin			426,393
Waterloo			189,628
Preston			106,243
Hespeler			48,095
Galt			246,939
Totals	$6,684,629	$9,354,611	$11,909,100

Note on Development "C."—"Distribution Costs" for municipalities not in commission have not been estimated. Therefore, the costs given from Hamilton to Galt are subject to extra loading for distribution. Toronto to Ingersoll include distribution.

The above Table indicates the apportionment of the capital costs of generation, transmission and distribution in the cases of Developments "A" and "B." Development "C" includes the division of the capital costs of generation, transmission and distribution for seven municipalities, and of generation and distribution only for the remaining eleven. The capital costs of the Niagara Plant have in each case been divided in proportion to the horse power required to be developed at Niagara for each municipality. Transmission line costs have been divided in proportion to the horse power required at Niagara, and the distance from Niagara for each municipality. Distribution costs have been apportioned each to its own municipality.

Table 17.—Part 2.

Site 3, Capital Costs—Niagara Development, Transmission and Transformation and Distribution Apportioned to Municipalities.

Municipalities	Development "A" 30,000 H. P.	Development "B" 60,000 H. P.	Development "C" 100,000 H. P.
Toronto	$5,043,677	$6,982,362	$6,708,654
London	927,378	1,175,209	1,000,041
Brantford	486,100	627,757	548,172
Guelph	361,238	468,957	407,755
Stratford	365,748	466,661	392,639
Woodstock	239,689	302,283	260,635
Ingersoll	245,272	310,871	265,884
Hamilton	....	....	1,315,251
St. Thomas	....	....	432,622
Paris	....	Subject	135,923
Dundas	....	to	74,019
Mitchell	....	addition	102,798
St. Mary's	....	of	138,367
Berlin	....	municipal	463,157
Waterloo	....	distribution	204,720
Preston	....	cost	114,193
Hespeler	....	....	51,520
Galt	....	....	264,543
Totals	$7,669,102	$10,334,100	$12,880,893

N.B.—The foot note appended to Table 17, part 1, also applies to this table, which covers cost of site 3, development.

Table 18.

Capital Costs—Niagara Development, Transmission and Transformation—Apportioned to Municipalities.

Municipalities.	Development "A," 30,000 H.P.	Development "B" 60,000 H.P.	Development "C," 100,000 H.P.
Niagara-Toronto System			
Toronto	$3,216,907	$4,815,237	$4,765,950
Niagara-London System			
London	602,628	790,721	640,550
Brantford	316,178	420,254	358,405
Guelph	235,930	314,038	266,473
Stratford	256,574	337,271	274,407
Woodstock	151,656	199,186	164,836
Ingersoll	160,292	209,929	172,292
Hamilton	....	....	1,163,812
St. Thomas	....	....	399,438
Paris	....	....	123,322
Dundas	....	....	66,359
Stratford Sub-system			
Mitchell	....	....	97,847
St. Mary's	....	....	130,136
Guelph Sub-system			
Berlin	....	....	426,393
Waterloo	....	....	189,628
Preston	....	....	106,243
Hespeler	....	....	48,095
Galt	....	....	246,939
Totals	$4,940,165	$7,086,636	$9,641,125

The above Table indicates capital costs, development, transmission and transformation in the same way as Table 17, part one, but omitting in every case the distribution costs.

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Table 19.

Yearly Operating Costs and Fixed Charges. Niagara Plant.

Items	Development "A" 30,000 H.P.	Development "B" 60,000 H.P.	Development "C" 100,000 H.P.
Wages	$17,004	$21,684	$21,684
General Expense and Contingencies	17,366	23,816	29,650
Government Rental for Power	32,500	47,500	67,500
Supplies	3,000	4,000	6,000
Maintenance	48,294	74,623	113,427
Interest	108,224	147,189	208,197
Sinking Fund	25,315	34,430	48,701
Total	$251,703	$353,242	$495,159
Cost per H.P. per annum	$8.39	$5.89	$4.95

The above Table shows the yearly operating costs of the Niagara Development for three developments, and includes all fixed charges, operating costs and Government rental for power, the latter on the basis of that already paid by existing companies. Allowance has also been made in general expense item for all contingencies, including compensation for accidents.

Table 20.

Yearly Operating Costs and Fixed Charges.
Transmission Lines and 60,000 and 10,000 V. Sub-stations.

Items	7 Municipalities Development "A" 30,000 H.P.	7 Municipalities Development "B" 60,000 H.P.	18 Municipalities Development "C" 100,000 H.P.
Wages	$39,364	$58,812	$82,940
General Expense	19,734	27,634	39,300
Supplies	3,500	3,500	6,500
Maintenance	64,049	93,316	121,126
Interest	114,083	171,708	225,651
Sinking Fund	26,684	40,165	52,784
Total	$267,414	$395,135	$528,301

The above Table indicates the yearly operating costs and fixed charges for the operation and maintenance of the transmission lines.

Development " A " for 7 Municipalities at half market.
" " B " " 7 " " full "
" " C " " 18 " " " "

Table 21.

Yearly Operating Costs and Fixed Charges—Municipal Distributing Plants—Arc Lighting—Seven Municipalities.

Items	Development "A" 30,000 H. P.	Development "B" 60,000 H. P.	Development "C" 100,000 H. P.
Wages	$17,032	$17,032	$17,032
General Expense	9,537	9,537	9,537
Supplies	11,279	11,279	11,279
Maintenance and Renewals	9,845	9,845	9,845
Interest	13,472	13,472	13,472
Sinking Fund	3,150	3,150	3,150
Total	$64,315	$64,315	$64,315

The above Table indicates the yearly operating costs and fixed charges for arc distribution within the municipal boundaries of the municipalities.

Note.—As previously explained, arc lighting is being considered as being a fixed quantity for developments "A," "B" and "C".

Table 22.

Yearly Operating Costs and Fixed Charges.
Municipal Distributing Plants—Incandescent Lighting—Seven Municipalities.

Items.	Development "A," 30,000 H.P.	Development "B," 60,000 H.P.	Development "C," 100,000 H.P.
Wages	$26,989	$26,989	$26,989
General Expense.	20,364	20,364	20,364
Supplies	48,384	48,384	48,384
Maintenance	44,005	44,005	44,005
Interest	49,803	49,803	49,803
Sinking Fund.	11,649	11,649	11,649
Total	$201,194	$201,194	$201,194

The above Table indicates the yearly operating costs and fixed charges for the incandescent distribution within the boundaries of the seven municipalities.

Note.—As previously stated, incandescent lighting is considered in all municipalities as being the same under the three developments.

Table 23.

Yearly Operating Costs and Fixed Charges.
Municipal Distributing Plants—Motor Service—Seven Municipalities.

Items	Development "A" 30,000 H.P.	Development "B" 60,000 H.P.	Development "C" 100,000 H.P.
Wages	$20,389	$20,389	$20,389
General Expense	20,364	20,364	20,364
Supplies	4,019	4,019	4,019
Maintenance	11,429	32,034	32,034
Interest	15,223	38,786	38,786
Sinking Fund	3,560	9,073	9,073
Total	$74,984	$124,665	$124,665

Note.—On Distributing Systems only seven municipalities have been estimated upon under the 100,000 H.P. development.

The above Table indicates the yearly operating costs and fixed charges for the municipal distributing plants for motor service in seven municipalities.

Note.—As before stated the amount of power available for sale to motor users is considered to be the market in each municipality, less amount required for arc and incandescent lighting, which are assumed as fixed.

Table 24.

Cost of Power per Horse Power per Annum at Niagara Falls Switchboard.

Cost for all Municipalities	Development "A" 30,000 H. P.	Development "B" 60,000 H. P.	Development "C" 100,000 H. P.
Toronto to Galt inclusive as per table No. 19	$8.39	$5.89	$4.95

The above Table indicates the cost of power per horse power per year at Niagara Falls switchboard for the three developments, derived from the yearly operating costs and fixed charges at Niagara as indicated in Table 19.

Table 25.

Cost of Power per H. P. per Annum delivered at Municipal Sub-station Switchboard.

Municipality	Development "A" 30,000 H. P.	Development "B" 60,000 H. P.	Development "C" 100,000 H. P.
Niagara-Toronto System.			
Toronto	$17.60	$13.19	$12.06
Niagara-London System.			
London	27.26	18.07	14.54
Brantford	20.55	13.73	11.37
Guelph	21.71	14.56	13.00
Stratford	27.62	18.02	15.99
Woodstock	24.37	16.37	12.85
Ingersoll	25.60	17.04	13.42
Hamilton	......	......	8.89
St. Thomas	......	......	15.09
Paris	......	......	12.19
Dundas	......	......	11.13
Stratford Sub-System.			
Mitchell	......	......	24.62
St. Mary's	......	......	19.67
Guelph Sub-System.			
Berlin	......	......	12.68
Waterloo	......	......	14.55
Preston	......	......	16.00
Hespeler	......	......	20.06
Galt	......	......	15.85

The above Table indicates the cost per horse power per year for power delivered at municipal sub-station switch board obtained by dividing the yearly operating costs of transmission lines as apportioned, plus the costs for power at Niagara, by the horse power delivered to the Municipality by the Transmission Commission as per Table 3.

Table 26.

Cost of Power at Consumers' Premises.

Arc Lighting—Cost per Lamp per Year.

Municipality	Development "A" 30,000 H.P.	Development "B" 60,000 H.P.	Development "C" 100,000 H.P.
Toronto	$42.02	$37.61	$36.48
London	54.08	44.89	41.36
Brantford	49.73	42.91	40.55
Guelph	47.84	40.69	39.13
Stratford	56.83	47.23	45.20
Woodstock	56.16	48.16	44.64
Ingersoll.	72.58	64.02	60.40

The above Table indicates the cost per arc lamp per year in seven municipalities under the three developments on the basis of the necessary power costs, as given in Table 25 with the addition of yearly distribution costs, chargeable to each municipality for this service, as given in Table 21.

Table 27.

Cost of Power at Consumers Premises.
Incandescent Lighting—Cost per K. W. H.

Municipality	Development "A" 30,000 H.P.	Development "B" 60,000 H.P.	Development "C" 100,000 H.P.
Toronto	$ .0741	$ .0640	$ .0614
London	.1150	.0925	.0839
Brantford	.0945	.0778	.0720
Guelph	.1140	.0965	.0926
Stratford	.1218	.0983	.0934
Woodstock	.1307	.1091	.0995
Ingersoll.	.1321	.1112	.1023

The above Table indicates the cost in each municipality at the consumers' premises for incandescent lighting for the three developments, on the basis of the necessary power for this service costing as per Table 25 with the addition of the yearly costs for distribution indicated in Table 22.

Table 28.

Cost of Power at Consumers' Premises.
Motor Service—Cost per H.P. per year.

Municipality	Development "A," 30,000 H.P.	Development "B" 60,000 H.P.	Development "C," 100,000 H.P.
Toronto	$21.97	$15.73	$14.60
London	53.07	23.87	20.34
Brantford	30.02	17.93	15.57
Guelph	27.68	18.26	16.70
Stratford	33.67	21.45	19.42
Woodstock	34.48	21.05	17.53
Ingersoll	33.96	21.61	17.99

The above Table indicates the cost per horse-power per year of power for motors delivered at the consumers' premises, and is obtained by considering the costs shown in Table 25, together with the additional costs of distribution for this service, as shown in Table 23.

Table 29.

Comparative Costs of Power—Sites 3 and 4 at Niagara Developed—Cost of Power per Horse-power per Year at Niagara Falls Switchboard.

	Development "A," 30,000 H.P.		Development "B," 60,000 H.P.		Development "C," 100,000 H.P.	
	Site 3	Diff. over Site 4	Site 3	Diff. over Site 4	Site 3	Diff. over Site 4
All Municipalities, Toronto to Galt inclusive	$10.63	$2.24	$7.00	$1.11	$5.62	.67

The above Table indicates the cost of power per horse-power per year at Niagara Falls switchboard for the three developments "A", "B" and "C", derived by dividing the yearly operating costs and fixed charges at Niagara (worked out similarly to Table 19 from Table 8 for site 3), by dividing the horse-power developed at the Niagara outgoing terminals as per Table 4.

Table 30.

Cost of Power per Horse Power at Low Tension side of the various Municipal Sub-Station Switchboards.

Municipality	Development "A" 30,000 H. P.		Development "B" 60,000 H. P.		Development "C" 100,000 H. P.	
	Site 3	Diff. over Site 4	Site 3	Diff. over Site 4	Site 3	Diff. over Site 4
Toronto	$20.24	$2.64	$14.50	$1.31	$12.86	.80
London	29.79	2.53	19.33	1.26	15.29	.75
Brantford	23.07	2.52	14.99	1.26	12.13	.76
Guelph	24.39	2.68	15.88	1.32	13.80	.80
Stratford	30.25	2.63	19.32	1.30	16.77	.78
Woodstock	26.95	2.58	17.66	1.29	13.63	.78
Ingersoll	28.20	2.60	18.33	1.29	14.20	.78
Hamilton	......	......	......	......	9.61	.72
St. Thomas	......	......	......	......	15.89	.80
Paris	......	......	......	......	12.95	.76
Dundas	......	......	......	......	11.86	.73
Mitchell	......	......	......	......	25.41	.79
St. Mary's	......	......	......	......	20.47	.80
Berlin	......	......	......	......	13.42	.74
Waterloo	......	......	......	......	15.31	.76
Preston	......	......	......	......	16.77	.77
Hespeler	......	......	......	......	20.88	.82
Galt	......	......	......	......	16.62	.77

The above Table indicates the cost per horse power per year for power delivered at Municipal sub-station switchboard made up on the principle set forth in the Note to accompany Table No. 25.

Table 31.

Comparative Cost of Power—Sites 3 and 4 at Niagara Developed—Cost of Power at Consumers' Premises—Arc Lighting—Cost per Lamp per Year.

Municipality	Development "A" 30,000 H.P.		Development "B" 60,000 H.P.		Development "C" 100,000 H.P.	
	Site 3	Diff. over Site 4	Site 3	Diff. over Site 4	Site 3	Diff. over Site 4
Toronto	$44.66	$2.64	$38.92	$1.31	$37.28	.80
London	56.61	2.53	46.15	1.26	42.11	.75
Brantford	52.25	2.52	44.17	1.26	41.31	.76
Guelph	50.52	2.68	42.01	1.32	39.93	.80
Stratford	59.46	2.63	48.53	1.30	45.98	.78
Woodstock	58.74	2.58	49.45	1.29	45.42	.78
Ingersoll	75.18	2.60	65.31	1.29	61.18	.78

The above Table indicates the yearly cost per arc lamp per year in 7 municipalities under the three developments, on the basis explained in note covering Table No. 26.

Table 32.

Comparative Cost of Power—Site 3 and 4 at Niagara Developed.
Cost of Power at Consumers' Premises. Incandescent Lighting—Cost per Kilowatt Hour.

Municipality	Development "A" 30,000 H. P.		Development "B" 60.000 H. P		Development "C" 100,000 H. P.	
	Site 3 $	Diff. over Site 4 $	Site 3 $	Diff. over Site 4 $	Site 3 $	Diff. over Site 4 $
Toronto	.0801	.0060	.0670	.0030	.0633	.0019
London	.1213	.0063	.0956	.0031	.0857	.0018
Brantford	.1007	.0062	.0809	.0031	.0739	.0019
Guelph	.1205	.0065	.0997	.0032	.0946	.0020
Stratford	.1282	.0064	.1015	.0032	.0953	.0019
Woodstock	.1377	.0070	.1126	.0035	.1017	.0022
Ingersoll	.1385	.0064	.1143	.0031	.1042	.0019

The above Table indicates the cost at the consumers' premises of incandescent lighting for the three developments, being obtained as explained in note to Table 27.

Table 33.

Comparative Cost of Power—Sites 3 and 4 at Niagara Developed—Cost of Power at Consumers' Premises—Motor Service—Cost per Horse-power per Year.

Municipality	Development "A," 30,000 H.P.		Development "B," 60,000 H.P.		Development "C," 100,000 H.P.	
	Site 3	Diff. over Site 4	Site 3	Diff. over Site 4	Site 3	Diff. over Site 4
Toronto	$24.61	$2.64	$17.04	$1.31	$15.40	.80
London	55.60	2.53	25.13	1.26	21.09	.75
Brantford	32.54	2.52	19.19	1.26	16.33	.76
Guelph	30.36	2.68	19.58	1.32	17.50	.80
Stratford	36.30	2.63	22.75	1.30	20.20	.78
Woodstock	37.06	2.58	22.34	1.29	18.31	.78
Ingersoll	36.56	2.60	22.90	1.29	18.77	.78

The above Table indicates the cost per horse-power per year of power for motors delivered at the consumers' premises, and is obtained as explained in note covering Table No. 28.

Table 34.

Yearly Cost of Steam Power per indicated Horse Power

		Full Load	75% Load
Indicated horse power of Plant	10 h.p.	$86.05	$111.50
" " " "	25 h.p.	65.41	78.00
" " " "	50 h.p.	47.42	57.50
" " " "	75 h.p.	43.29	53.50
" " " "	100 h.p.	39.05	48.00
" " " "	150 h.p.	33.34	40.60
" " " "	250 h.p.	26.87	32.00
" " " "	500 h.p.	22.61	27.80
" " " "	750 h.p.	20.32	24.00

The above Table indicates the yearly cost per indicated horse power of steam power generated at present within the municipalities on the basis.

1st. That the plant is loaded to its rated capacity;
2nd. That only 75% of its rated capacity is normally used.

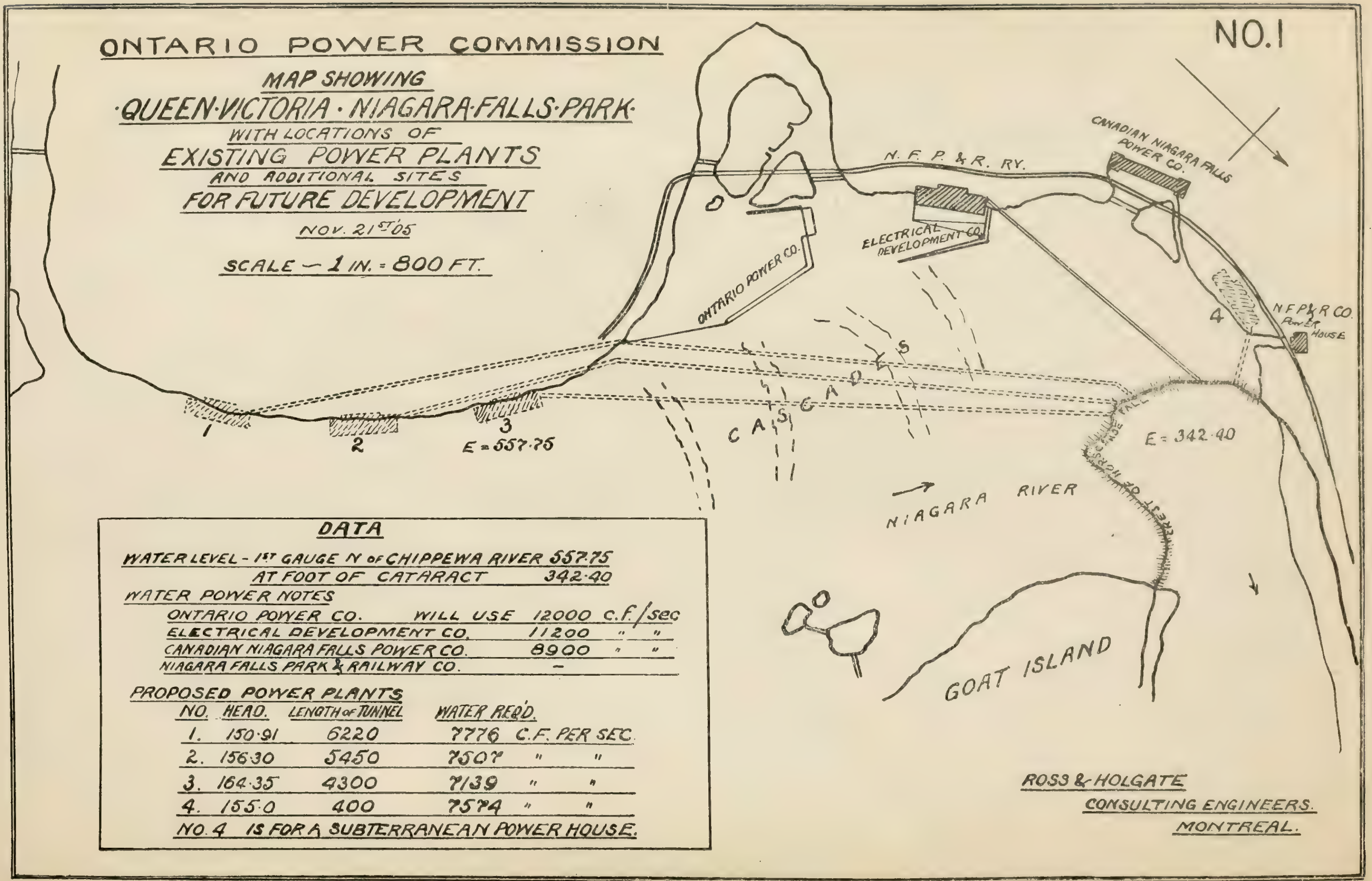
This Table is intended to apply to the average industrial plant throughout the district, using coal only and operating 10 hours per day, and does not apply to 24 hour plants, such as lighting, railway and pumping stations, operating 24 hours per day. The costs include all wages, coal, supplies, repairs and fixed charges.

Table 35.

Yearly Cost of Steam and Gas Power per Brake Horse Power.

		Full Load		75% Load	
		Steam	Gas	Steam	Gas
Indicated horse power of Plant...	10 h.p.	$98.95	$63.00	$128.22	$81.23
“ “ “	25 h.p.	75.72	45.00	89.70	57.67
“ “ “	50 h.p.	53.35	32.00	64.70	41.73
“ “ “	75 h.p.	47.62	28.00	58.85	37.52
“ “ “	100 h.p.	42.95	27.00	52.80	33.10
“ “ “	150 h.p.	36.67	24.00	44.66	30.36
“ “ “	250 h.p.	29.55	22.00	35.20	28.00
“ “ “	500 h.p.	24.26	17.00	30.58	21.52
“ “ “	750 h.p.	21.84	16.00	25.80	19.70

The above Table indicates the comparison between the costs of developing power from steam by the use of producer gas plants and gas engines on the same basis as Table 29, except that for purposes of comparison brake horse power is used instead of indicated horse power.



NO. 1

ONTARIO POWER COMMISSION

MAP SHOWING
·QUEEN·VICTORIA·NIAGARA·FALLS·PARK·
WITH LOCATIONS OF
EXISTING POWER PLANTS
AND ADDITIONAL SITES
FOR FUTURE DEVELOPMENT
NOV. 21ST 05

SCALE — 1 IN. = 800 FT.

DATA

WATER LEVEL - 1ST GAUGE N OF CHIPPEWA RIVER		557·75
	AT FOOT OF CATARACT	342·40

WATER POWER NOTES

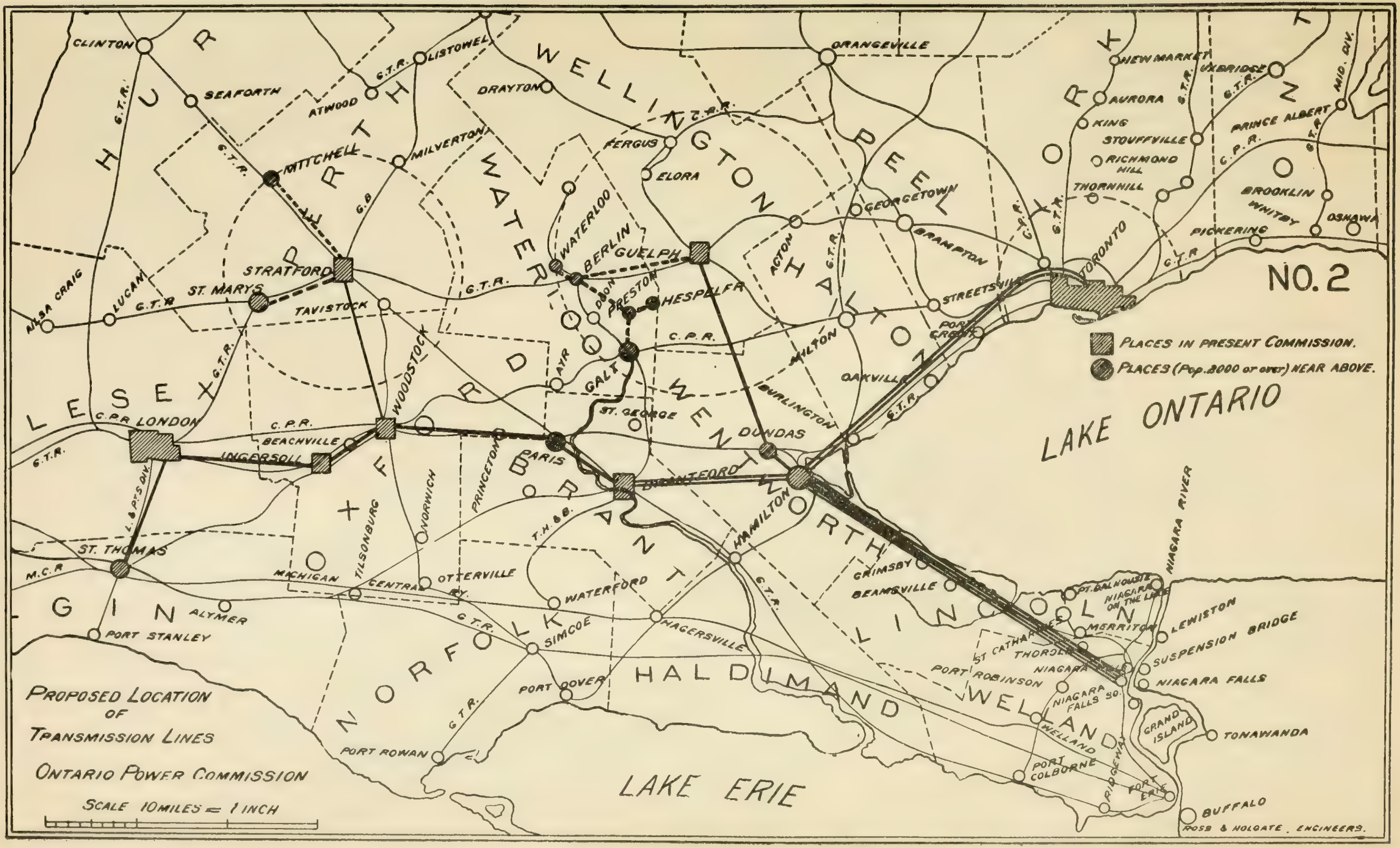
ONTARIO POWER CO.	WILL USE	12000 C.F./SEC
ELECTRICAL DEVELOPMENT CO.		11200 " "
CANADIAN NIAGARA FALLS POWER CO.		8900 " "
NIAGARA FALLS PARK & RAILWAY CO.		—

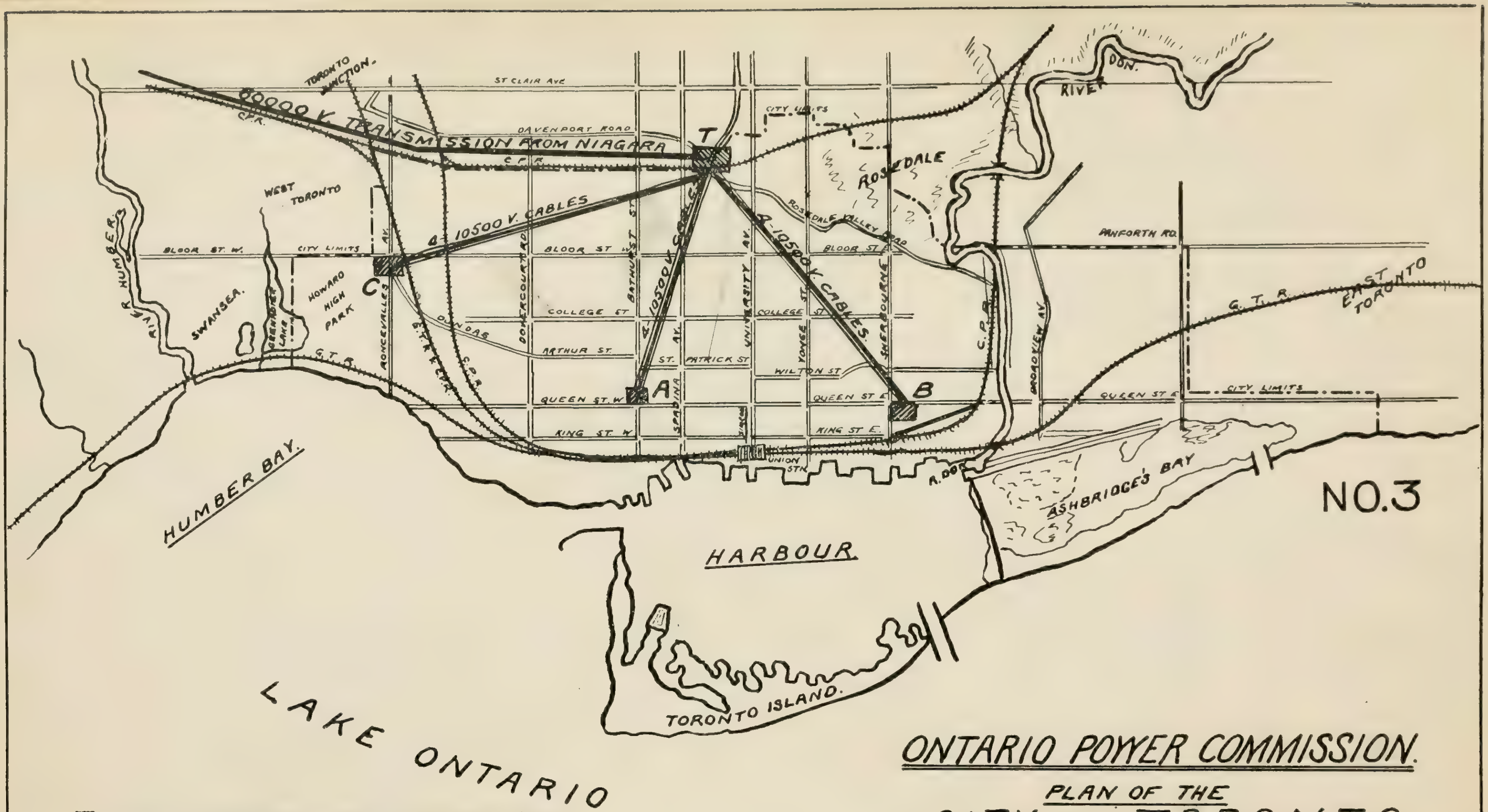
PROPOSED POWER PLANTS

NO.	HEAD.	LENGTH OF TUNNEL	WATER REQ'D.
1.	150·91	6220	7776 C.F. PER SEC.
2.	156·30	5450	7507 " "
3.	164·35	4300	7139 " "
4.	155·0	400	7574 " "

NO. 4 IS FOR A SUBTERRANEAN POWER HOUSE.

ROSS & HOLGATE
CONSULTING ENGINEERS.
MONTREAL.


NO. 2
Places in present Commission.
Places (Pop. 2000 or over) near above.
Proposed Location of Transmission Lines
Ontario Power Commission
Scale 10 miles = 1 inch
Ross & Holgate, Engineers.
LAKE ONTARIO
LAKE ERIE
HURON
PERTH
WELLINGTON
PEEL
YORK
ONT
WATERLOO
HALTON
WENTWORTH
OXFORD
BRANT
MIDDLESEX
ELGIN
NORFOLK
HALDIMAND
LINCOLN
WELLAND
CLINTON
SEAFORTH
ATWOOD
LISTOWEL
DRAYTON
ORANGEVILLE
NEW MARKET
AURORA
KING
STOUFFVILLE
RICHMOND HILL
THORNHILL
UXBRIDGE
PRINCE ALBERT
BROOKLIN
WHITBY
OSHAWA
PICKERING
TORONTO
MITCHELL
MILVERTON
FERGUS
ELORA
GEORGETOWN
BRAMPTON
STREETSVILLE
PORT CREDIT
ACTON
MILTON
OAKVILLE
BURLINGTON
DUNDAS
HAMILTON
GUELPH
BERLIN
WATERLOO
DOON
PRESTON
HESPELER
GALT
AYR
ST. GEORGE
PARIS
BRANTFORD
STRATFORD
ST. MARYS
TAVISTOCK
LUCAN
AILSA CRAIG
LONDON
WOODSTOCK
BEACHVILLE
INGERSOLL
PRINCETON
NORWICH
TILSONBURG
OTTERVILLE
ST. THOMAS
ALYMER
PORT STANLEY
WATERFORD
SIMCOE
HAGERSVILLE
PORT DOVER
PORT ROWAN
GRIMSBY
BEAMSVILLE
ST CATHARINES
THOROLD
MERRITON
PT. DALHOUSIE
NIAGARA ON THE LAKE
NIAGARA
NIAGARA FALLS SO.
PORT ROBINSON
WELLAND
PORT COLBORNE
RIDGEWAY
FORT ERIE
NIAGARA RIVER
LEWISTON
SUSPENSION BRIDGE
NIAGARA FALLS
GRAND ISLAND
TONAWANDA
BUFFALO
G.T.R.
C.P.R.
G.B.
MID. DIV.
M.C.R.
MICHIGAN CENTRAL RY.
L. & P.S. DIV.
T.H. & B.



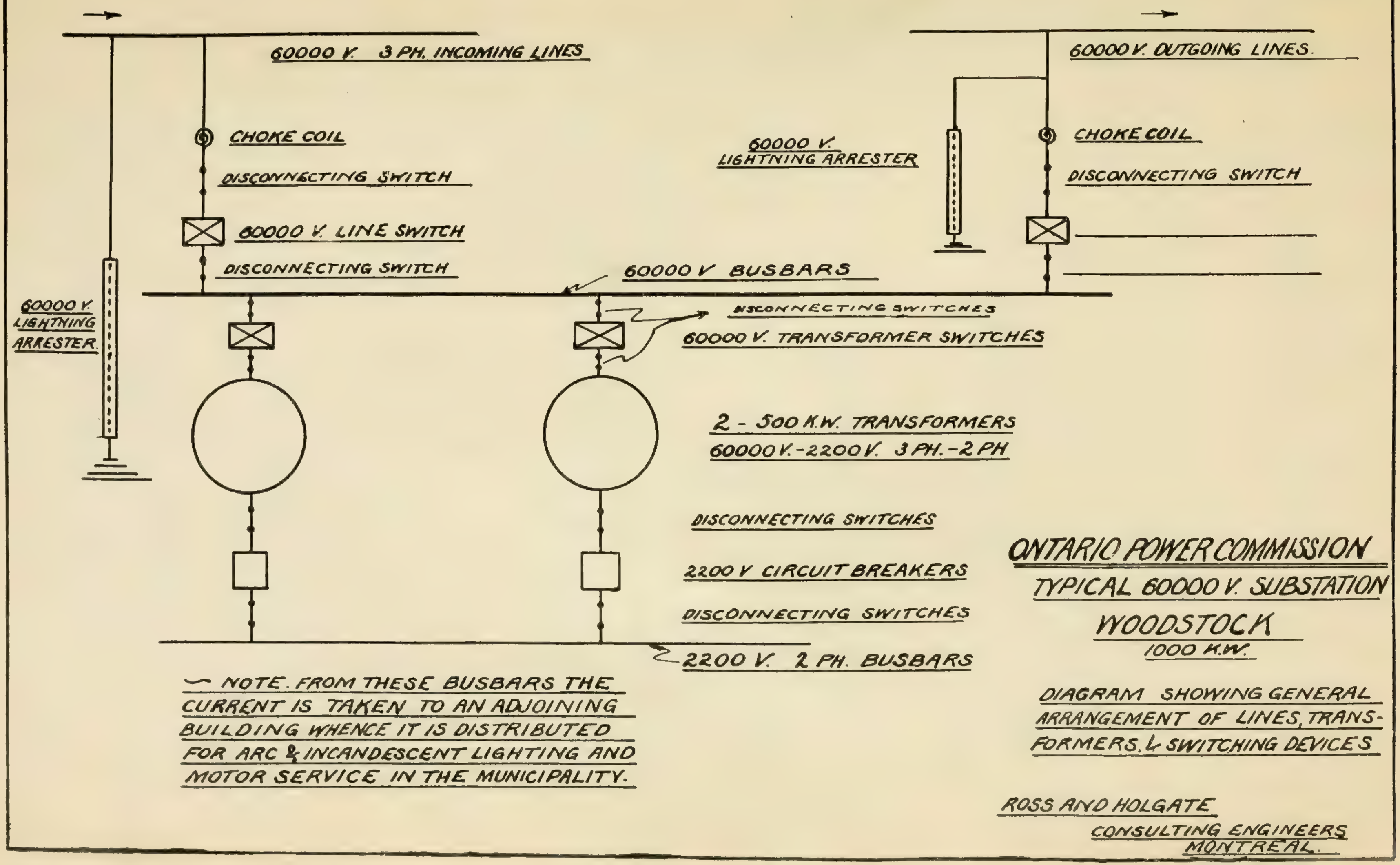
ONTARIO POWER COMMISSION.

PLAN OF THE
CITY OF TORONTO
SHOWING LOCATIONS
54000v.-11050v. TERMINAL STATION AND THE
THREE 10500v-2200v. DISTRIBUTING STATIONS
OF THE TRANSMISSION SYSTEM, NIAGARA TO TORONTO.

ROSS & HOLGATE
CONSULTING ENGINEERS, MONTREAL

T. TERMINAL STATION, CORNER OF DUPONT AV. AND POPLAR PLAINS ROAD.
A. DISTRIBUTING STATION AT CORNER OF QUEEN AND BATHURST STS. - 9600' FROM T.
B. DISTRIBUTING STATION, CORNER OF QUEEN AND SHERBOURNE STS. - 16000' FROM T.
C. DISTRIBUTING STATION, CORNER OF ALHAMBRA AND BLOOR STS. - 16000' FROM T.

NO.4



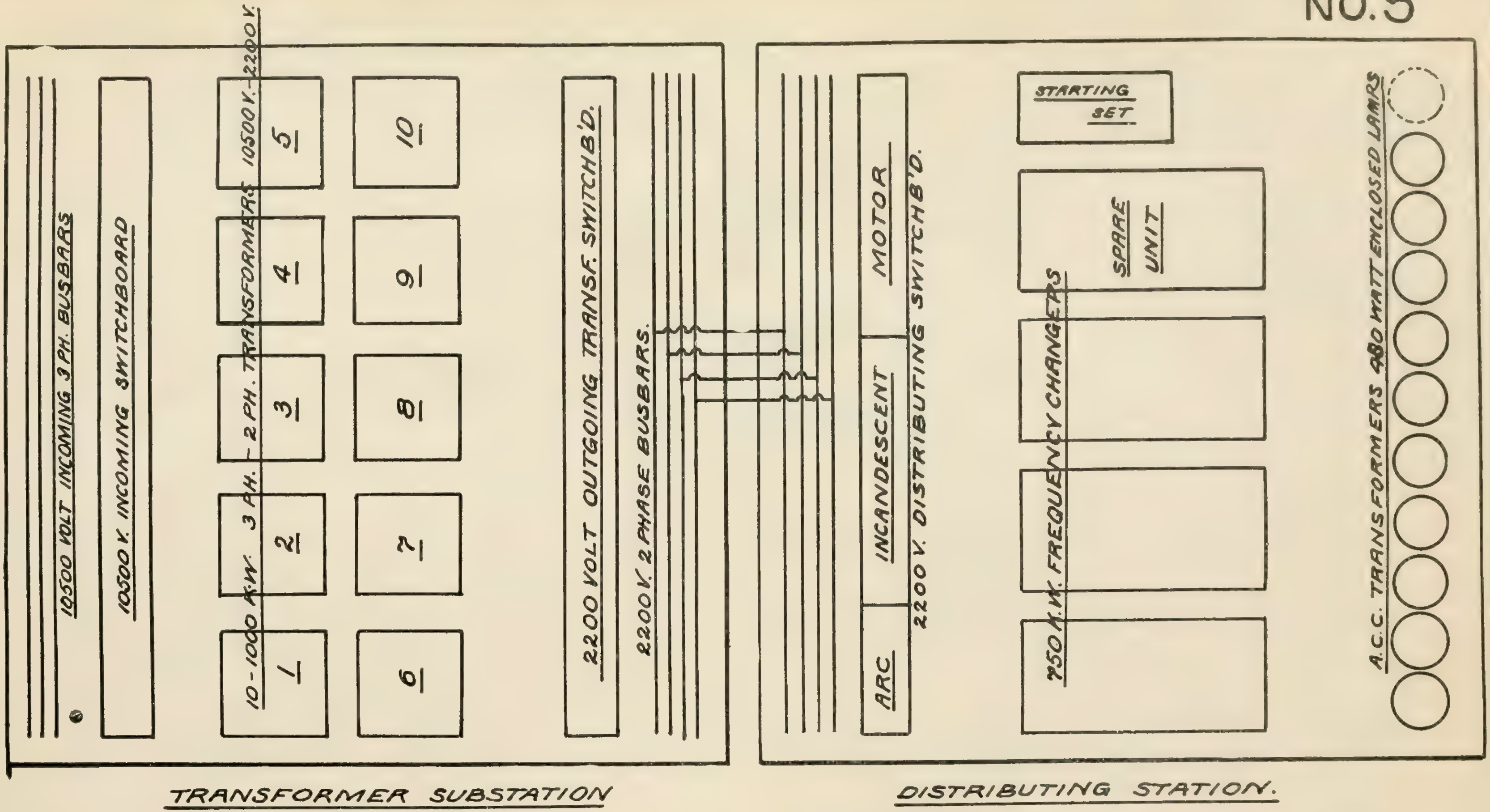
NOTE. FROM THESE BUSBARS THE CURRENT IS TAKEN TO AN ADJOINING BUILDING WHENCE IT IS DISTRIBUTED FOR ARC & INCANDESCENT LIGHTING AND MOTOR SERVICE IN THE MUNICIPALITY.

ONTARIO POWER COMMISSION
TYPICAL 60000 V. SUBSTATION
WOODSTOCK
1000 K.W.

DIAGRAM SHOWING GENERAL ARRANGEMENT OF LINES, TRANSFORMERS, & SWITCHING DEVICES

ROSS AND HOLGATE
CONSULTING ENGINEERS
MONTREAL.

NO. 5


10500 VOLT INCOMING 3 PH. BUSBARS
10500 V. INCOMING SWITCHBOARD
10-1000 K.W. 3 PH. - 2 PH. TRANSFORMERS 10500 V.-2200 V.
1
2
3
4
5
6
7
8
9
10
2200 VOLT OUTGOING TRANSF. SWITCHB'D.
2200 V. 2 PHASE BUSBARS.
ARC
INCANDESCENT
MOTOR
2200 V. DISTRIBUTING SWITCHB'D.
750 K.W. FREQUENCY CHANGERS
SPARE UNIT
STARTING SET
A.C.C. TRANSFORMERS 480 WATT ENCLOSED LAMPS
TRANSFORMER SUBSTATION
DISTRIBUTING STATION.

ONTARIO POWER COMMISSION

DIAGRAM PLAN SHOWING TORONTO
TRANSFORMER & DISTRIBUTING ST'NS

ROSS & HOLGATE
CONSULTING ENGINEERS MONTREAL